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Broad-headed snake (*Hoplocephalus bungaroides*) from Kangaroo Valley, NSW. See paper on page 37 (photo: M. Murphy).



Macquarie River turtle (*Emydura macquarii*) hatching. See paper on page 1 (photo: D. Green).



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## CONTENTS

### Volume 26 No 2

Observations of reproduction in a southern population of Macquarie River turtles, <i>Emydura macquarii</i> .	
by Darren Green .....	2
Further evidence of orthopteran invertebrates as regular prey for the Lowlands Copperhead <i>Austrelaps superbis</i> (Serpentes: Elapidae) in Tasmania.	
by Simon Fearn & Bruce Munday .....	6
A survey of the frog fauna of Redhead Lagoon, Awabakal Nature Reserve, New South Wales.	
by Andrew J. Hamer .....	8
Possible overwintering on land by hatchling <i>Chelodina longicollis</i> .	
by A.A.G. Raka Dalem & Shelley Burgin .....	14
The baiting of pitfall traps with vegetable oils – its effect on the captures of herpetiles in a coastal lowland community.	
by David S. Hannah & Geoffrey C. Smith .....	16
Successful breeding of the Diamond python ( <i>Morelia s. spilota</i> ) in the wet/dry tropics of Northern Australia.	
by Gavin S. Bedford .....	19
The Dugite or Spotted Brown snake <i>Pseudonaja affinis</i> .	
by Brad Maryan & Brian Bush .....	22
Communal egg-laying in the Broad-tailed gecko ( <i>Phyllurus platurus</i> ).	
by Gerry Swan & Harald Ehmann .....	35
A possible threat to the Broad-headed snake <i>Hoplocephalus bungaroides</i> : degradation of habitat by the feral goat <i>Capra hircus</i> .	
by Michael J. Murphy .....	37
Some litters of the Eastern Blue-tongued skink <i>Tiliqua scincoides scincoides</i> (Scincidae)	
by Grant Turner .....	39

## HERPETOLOGICAL NOTES

Partial tongue regeneration in a captive Black-headed python <i>Aspidites melanocephalus</i> (Krefft, 1864).	
by Robert A. Valentic .....	48
Nocturnal activity by <i>Varanus panoptes</i> at Cape Melville.	
by Steve Irwin, Barry Lyons & Tony Frisby .....	50
Burrow plugging by the Fat-tailed gecko, <i>Diplodactylus conspicillatus</i> .	
by Cheryl Baker & Bayard H. Brattstrom .....	51
Rediscovery of the Striped Legless lizard, <i>Delma impar</i> (Pygopodidae) on the Monaro Plains of NSW.	
by J.W. Dorrough, P. Close & L. Williams .....	52
Book reviews .....	54
Erratum .....	48
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# OBSERVATIONS OF REPRODUCTION IN A SOUTHERN POPULATION OF MACQUARIE RIVER TURTLES, *EMYDURA MACQUARII*

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## ABSTRACT

Observations of nesting behaviour and artificial incubation of eggs in the aquatic chelid turtle *Emydura macquarii* were made during the period of 1986 to 1995 in the Bendigo area, central Victoria. Nesting occurred from mid November to late December. Under artificial incubation eggs hatched the following January, some 50 to 60 days later. Behaviour of the parent female turtle prior to and during nesting is briefly described with a detailed description of the hatching of neonates. Comparative data of nesting activity, clutch sizes and incubation in southern population of *Emydura macquarii* is made.

## INTRODUCTION

The Macquarie River Turtle, *Emydura macquarii*, is a short-necked species of freshwater turtle inhabiting rivers and lakes throughout the Murray River system in Victoria, central New South Wales and southern central Queensland (Cann 1978). Nesting in *E. macquarii* generally occurs from November to December depending on the locality and prevailing climate (Cann 1978). Nest construction is described by Goode (1965).

Detailed observations of the nesting behaviour of marine turtles are common in species accounts (eg. Bustard 1972, Carr 1952, Pritchard & Trebbau 1984). For Australian freshwater turtles there are only anecdotal accounts for nesting behaviour in the literature. There is also limited information regarding the behavioural characteristics which are displayed by hatching neonates in the field because they are hidden from observation within the nest. Captive observations of hatchling help to fill this gap.

## Materials and Methods

The study site is located at Lake Weeroona in Bendigo (36°48'S, 144°21'E) Victoria, the southern most extent of *E. macquarii*'s geographic range in Victoria. Observations of

nesting behaviour were done by torchlight following late spring/summer rains and thunderstorms.

All eggs were removed from randomly selected nests immediately after laying, or within six hours of laying, and retained for artificial incubation. Incubators initially consisted of one aquarium placed inside another aquarium (Wilke 1979, Green 1991). Later a plastic lunch box containing eggs was placed in a box heated with two 60w globes connected to a thermostat. The incubation medium was dampened peatmoss or vermiculite (Green 1991). The third method of incubation used a sand filled aquarium with the eggs buried to a depth of 100mm in the dampened sand and left in a warm room to incubate 'naturally'. All juveniles were returned to Lake Weeroona within 7 days of hatching.

## Nesting Behaviour

In the Bendigo region nesting occurs from mid November to mid December. During 1986 to 1993, nesting occurred on evenings following summer rains and thunderstorms associated with warm to hot days. During 1994, Bendigo experienced drought conditions and scattered rains were misty with little rain actually falling. This had a marked effect on the Lake Weeroona population of turtles – there was little nesting activity and those that nested did so during or just after rainfall regardless of the time of day.

My observations showed that female *E. macquarii* move close to the bank and waited until the sun had set before climbing ashore to begin nest excavation. Observations of the digging process were not possible as the turtles would return to the water at my approach – this disruption sometimes happened several times during an evening. Once the digging process was finished and egg laying had begun, their shy nature changes to one of being 'ignorant of their surroundings' or 'trance like' (as has been described in marine turtles)



and observations of the rest of the nesting process was possible.

Nest sites were chosen in an open area, usually within 2m of the water's edge and no further away than 40m. Nest depth was estimated between 150 to 200mm and flask shaped. Only certain areas around the lake were used as nesting sites from year to year. These areas were quite open and the closest tree was about 3m away.

One egg is deposited into the egg chamber at a time and an audible 'clink' can be heard as the eggs collide inside the nest. The turtle uses one of its rear limbs to position the egg once deposited into the chamber. After all the eggs have been laid, the turtle uses one of its rear limbs to scrape the previously excavated dirt back into the hole to cover the eggs, and then returns to the water. Compacting the soil with the plastron observed by Goode (1965) was not observed at Lake Weeroona – perhaps my presence disturbed the turtle once the eggs were covered.

At Lake Weeroona an area projects out of the water forming an 'island' which is a popular nesting site with *E.macquarii*. In the 1993 nesting season four clutches were deposited 100mm apart on this island. This nesting process occurred within approx. 1 hour, resulting in a somewhat crowded nesting scenario.

### **Egg Description**

Freshly laid eggs of *E.macquarii* are hard shelled with an inner leathery membrane, translucent in colour and elongate with rounded ends. A matt white patch appears on the top of the eggs which forms a band around the center and spreads to the ends during the course of incubation (Thompson 1985). Egg dimensions from the Lake Weeroona population of *E.macquarii* measured 34.25mm mean length (range 31.0-39.9) and 21.71mm mean width (range 20.0-23.0), obtained from 371 eggs. A mean clutch size of 24.6 eggs (range 16-30) was obtained from 16 nests.

### **The Hatching Process**

The number of days from deposition to pipping

of the egg under artificial incubation was 59-69 days (26°C), 50-60 days (29°C) and 40-52 days (30°). Hatching is initiated by the neonate piercing the egg with its egg tooth (caruncle), which is visible below the nostrils and above the mouth. The egg is pierced towards one end in several places and enlarged by a pushing action of the neonates front limbs. The brittle outer part of the egg breaks away in pieces while the inner leathery membrane is torn during the piercing and pushes further with the front limbs to enlarge the hole.

During the process of emergence, the neonates carapace and plastron is pliable and flexes to fit through the torn hole in the egg. The turtles anterior plastral lobe and carapace move together, while the front legs push the turtle through the egg opening. The turtle will emerge either plastron up or plastron down. If the turtle is emerging plastron down, the front limbs may drag the egg along with it. Although not visible, it is assumed the rear limbs do the pushing.

Once the turtle has pushed its way past where the carapace and plastron meet (plastral bridge), the posterior plastral lobe and carapace move together resulting in the anterior plastral lobe and carapace expanding out. The turtles body literally squeezes through the torn egg opening. Once the turtle can get hold of the egg opening with a rear limb it gives a final push and emerges completely from the egg.

The turtle will rest during the process and can take up to three days (if the temperature is cool) to fully emerge from the egg. In some instances the yolk sac may hinder emergence by catching on part of the egg opening, resulting in a time delay. On one occasion a smaller 'stillborn' turtle was also attached to the yolk sac which became snagged on the egg shell as it was dragged from the egg.

One clutch of eggs were buried in a sand-filled glass aquarium so that the hatching process could be observed under a 'natural' environment. After the first turtle emerged from the egg, it dug a chamber above the eggs with its



front limbs. It continued digging upwards with the occasional rest, until it reached the sand surface. Here it left the chamber in a tight fitting 'kidney' shaped hole and wandered around the aquarium. The remaining turtles pushed aside any empty eggs and sand and followed the tunnel to the surface. With each emergence the hole was enlarged. The depth of the tunnel was 100mm and it took two days for the first turtle to emerge from the egg chamber.

### Juvenile Description

Newly emerged *E.macquarii* hatchlings are soft, flexible and 'slimy' to touch. They have a round carapace and the hind peripheral plates are folded towards the plastron. The centre part of the plastron, between the plastral bridge, is folded and overall appears ball-like in shape. As the carapace dries and hardens, it tends to flatten and the peripheral plates lift. The drying and hardening takes up to twenty minutes. The egg tooth or caruncle is still visible and drops off within three days. Hatchlings measure 31.0mm x 29.0mm (mean) over the carapace after drying.

The typical *E.macquarii* juvenile has a pale yellow-brown plastron with narrow lobes. Occasionally a grey 'smudge' may be present between the plastral bridges where the yolk sac was attached. The carapace varies in colour from a pale to dark olive with individual scutes having a dark blotch posteriorly, becoming peppered and fading with growth. A ridge extends down the back of the carapace, which flattens with growth (although still apparent at 100mm carapace length), and the rear marginals are serrated. Skin colouration is grey to an olive grey on the head shield and becoming grey all over with age. A pale yellow stripe extends along the neck from the corner of the mouth, and another stripe present along the underside of the lower jaw. A pale yellow spot may also be present behind each eye but is less common.

### DISCUSSION

Nesting has been recorded at Lake Weeroona

between 17 November and 20 December with an additional observation on 25 December. Goode (1965) records a nesting at Patho (Vic.) between 2 November and December with an additional captive nesting on 9 January at his Melbourne suburb home. This captive female originated from Patho. Goode & Russell (1968) record nesting 5 miles south of the Murray River between 29 October and 15 December. Among temperate zone Australian chelids nesting may begin as early as August in warmer areas (Georges in Legler & Georges 1993) and as late as November in cooler areas (Vestjens in Legler & Georges 1993) with multiple clutching occurring throughout each species range (Legler in Legler & Georges 1993). The Lake Weeroona *E.macquarii* population is regarded as being on the southern-most limit of their naturally occurring geographic range in Victoria. As a result there is a tight seasonal response, nesting starts later and the possibility of multiple clutches is reduced.

Courtship and copulatory behaviour of *E.macquarii* is described by Murphy & Lamoreaux (1978) and Corwin (1985) where air temperature varied between 26 to 35°C, relative humidity was approximately 50% with 9 hours of light under captive conditions. This 'climate' is similar to Central Victoria's spring season when courtship and copulation is assumed to take place. Under captive conditions the author has induced courtship behaviour in males mid-September in glass aquariums. A congregation of 33 individuals were also observed in a small shallow section (100m<sup>2</sup>) of Lake Weeroona on 26 October 1994. Although mating was not observed this was an unusual occurrence at this site. Based on these observations, a gestation period prior to egg deposition is estimated at 18 to 48 days in central Victoria.

Clutch size also appears responsive to the southerly climate. Lake Weeroona clutches (N=16) averaged 24.6 eggs (range 16-30) in comparison with Goode & Russell (1968) clutch size (N=9) averaged 15.3 (range 6-24).



Egg dimensions recorded from captive breedings (Banks 1983, Corwin 1985, Goode 1965 & Goode 1967) range 31.8 to 37.0mm in length and 21.2 and 24.0mm in width. Egg dimensions from the Lake Weeroona population (N=371) were 34.25mm mean length (range 31.0-39.9) and 21.71mm mean width (range 20.0-23.0), generally agreeing with captive results.

The number of days from egg deposition to pipping of the egg under artificial incubation was recorded at 59-69 days (26°C), 50-60 days (29°C) and 40-52 days (30°C). Field observations by Goode (1967) and Goode & Russell (1968) record incubation at 78 days (temp. not recorded) and 66-85 days (14.1-28.3°C) respectively, Thompson (1988) recorded nest temperatures in the field in more detail.

Old nest sites from previous years at Lake Weeroona were easy to identify. A shallow hole was left as a result of egg predation from rats and occasionally the nests were tunnelled out and made into homes for these rats. Rats and their 'homes' were more prevalent at known nesting sites of turtles. Estimated predation on known turtle nests not used in this study is estimated at 98%. Other inhabitants of Lake Weeroona are a variety of water birds and introduced fish and it is assumed that these animals are predators of hatchling turtles. Juveniles are very secretive, or mortality appears high as despite the number of juveniles returned to the lake only 3 have been recaptured over the study period.

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# FURTHER EVIDENCE OF ORTHOPTERAN INVERTEBRATES AS REGULAR PREY FOR THE LOWLANDS COPPERHEAD *AUSTRELAPS SUPERBUS* (SERPENTES: ELAPIDAE) IN TASMANIA

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Insects are rarely predated upon by snakes anywhere in the world. Mushinsky (1987) provides a summary of literature records for the primary prey of snakes. Of 112 species listed, comprising all families, only eight were recorded as specifically including insects in their diets. Of 29 elapids listed, only one, the Asiatic cobra, *Naja naja* was recorded as predating on insects.

Australian elapids also rarely predate upon insects or any other invertebrate group. Shine (1991) summarises the food habits of 74 species of Australian elapids with a breakdown in percentage of dietary preferences. Only seven species (*Austrelaps labialis* 4% (of prey items examined), *A. ramsayi* 3%, *Denisonia devisi* 2%, *D. maculata* 5%, *Drysdalia coronata* 3%, *Pseudechis australis* 1%, *P. guttatus* 12%) occasionally predate upon invertebrates, possibly only when more regular prey species are scarce and random opportunities to capture and ingest invertebrates present themselves. In addition Annable (1996) records an adult wild caught, captive *Echiopsis curta* capturing and ingesting large brown moths.

The ecology and food habits of Tasmanian *Austrelaps superbus* have been described by Shine (1987) and Fearn (1994, 1995). Tasmanian *A. superbus* are relatively unselective, searching foragers predating on a wide range of small vertebrates, mainly lizards and frogs, which are abundant in the open low lying riparian habitats favoured by this snake. Fearn (1994) records adult *A. superbus* actively pursuing, capturing and ingesting flightless grasshoppers (Orthoptera: Acridae). One of the authors (B.M.) observed this behaviour while walking through remnant eucalypt woodland interspersed with grassland in the

Hummocky Hills area in Tasmania's midlands, 35km south of Launceston. The feeding behaviour of an adult male *A. superbus* (approx. 1100mm total length) was observed at close range (1 metre) as it foraged up the grassy slope of a dam wall.

The object of the snake's attention proved to be immature (wingless, hopping stage) grasshoppers, 10-15mm in length which were present in large numbers. The observer's progress through the more open areas of grass being marked by a general exodus consisting of hundreds of these insects dispersing into low, interwoven grass roots and stems. The *A. superbus* was moving through a coarse, dry, somewhat homogenous mat of interwoven, mostly short (3-15cm) grass interspersed with low patches of buzzy plants *Acaena novaezeelandiae*.

The *A. superbus* made its way slowly up the slope moving over the top of the vegetation at a more or less oblique angle using numerous bends of the caudal two thirds of the body to maintain traction while casting about with the forebody for secure points of support. This process causing enough disturbance to displace dozens of grasshoppers which would relocate a short distance (10-30cm) further up the slope, seeking refuge in the thicker grass clumps and *A. novaezeelandiae* patches.

The snake ceased its forward movement at this stage and investigated any of these refuges within easy reach, carefully introducing the head and a short section (approx. 10cm) of the neck into the clump, usually followed by a very short sideways lunge which created little disturbance within the vegetation. In most cases a prey item would be secured and the snake's head would be partially withdrawn from cover allowing one to clearly



observe the rapid ingestion of the insect, after which the snake would continue investigating the refuge.

It was noted that the grasshoppers once concealed in such a clump would usually remain still and only attempt to crawl through it away from the immediate vicinity of the snake's intruding head, rather than resort to hopping into the open.

The snake having finished its investigation of the clump then proceeded to move further up the slope, repeating the whole process as described. The observations continued for 45 minutes until the snake reached the top of the slope whereupon it became aware of the observer's presence and retired into thicker cover.

The snake's head was partially concealed within vegetation on most occasions so only a dozen grasshoppers were clearly observed to be consumed during the 45 minute observation however the snake's actions indicated that many more were ingested during that time.

On 13/2/95 an adult male *A.superbus* (SVL 900mm, Wt 510 grams) was examined as a road kill at East Lagoon on the outskirts of Longford, northern Tasmania. Stomach contents consisted of an adult skink, *Niveoscincus metallica* and an entire recently ingested adult yellow winged locust *Gastrimargus musicus* 40mm in body length. *G.musicus* is common in open grassy habitats in Tasmania, sometimes forming dense aggregations (pers. obs.). Hughes (1975) records similar habitat preferences and behaviour for mainland *G.musicus*. Both authors have on many occasions observed *G.musicus* when conducting field work on *A.superbus*.

With three confirmed records of Tasmanian *A.superbus* actively preying on orthopteran insects it is possible that such prey are more commonly taken than is currently appreciated. When it is considered that such insects commonly share the same open grassy habitats, and dense low herbage microhabitats as foraging *A.superbus*, it is possible they are fre-

quently disturbed by foraging snakes particularly when such insects are present in high population densities. As recorded in a previous work (Fearn, 1994) *A.superbus* is a highly visual and energetic predator and will pursue active prey through dense vegetation.

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# A SURVEY OF THE FROG FAUNA OF REDHEAD LAGOON, AWABAKAL NATURE RESERVE, NEW SOUTH WALES

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## ABSTRACT

A survey of the frog fauna of Redhead Lagoon in the Awabakal Nature Reserve on the central coast of New South Wales was conducted between mid-August and early December 1992, with an additional survey in mid-February 1996. The study area was sampled during the day and night 2-3 times per week. A total of 12 species were identified as being present in the study area, representing two families and six genera. The breeding activity data and relative abundance for each species was tabulated according to the species habitat preferences. The *Melaleuca* vegetation community contained the highest species abundance and diversity. The frog faunal assemblage of Redhead Lagoon is present in a region of overlap between New South Wales south and north coast frog fauna. The aim of recording the species presence and abundance was to provide a baseline for future monitoring studies in the area.

## INTRODUCTION

Redhead Lagoon is a moderate sized freshwater body located along the coast of the Hunter Region in New South Wales. Since there is little information on the frog fauna breeding in the lagoons of this section of coast, the opportunity was taken to survey the frog fauna composition in the immediate vicinity of Redhead Lagoon. Such surveying was undertaken so that future changes in this fauna can be documented.

The lagoon is unique in that it is elevated approximately 65 metres above sea level and is the only water body to be situated at such a height along the Newcastle coastline. Other coastal freshwater lagoons which exist in the Hunter region occur at or close to sea level, such as those associated with the Myall Lakes

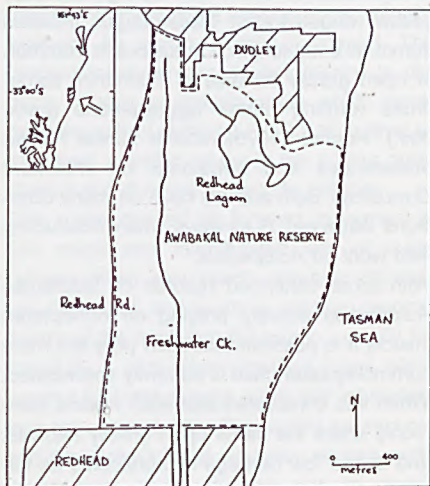
system, located approximately 70 kilometres to the north of Newcastle.

The aim of the survey was to determine the frog fauna composition in the immediate vicinity of Redhead Lagoon. A list of the species recorded during the survey is included with notes on each species abundance and habits. A brief consideration of distributional and seasonal factors influencing the species composition is also discussed. To my knowledge no previous assessment of the frog fauna of Redhead Lagoon has been made.

## Study Area

Redhead Lagoon is located within the Awabakal Nature Reserve (32°59'40"S 151°43'15"E) which occupies approximately 120 hectares of coastal land between the township of Dudley to the north and Redhead to the south, some 15 kilometres south of the city of Newcastle (Figure 1).

**Figure 1. Location of Redhead Lagoon and Awabakal Nature Reserve**





The lagoon is of irregular shape, with a large western section connected to a smaller eastern portion. The eastern section contains the most extensive area of open water and here the maximum depth is 2.2 metres. The lagoon is 65.8 metres above sea level and 12.1 hectares in area, lying in a depression on a high headland of sandstone.

To the north-west, north and north-east the lagoon backs into steeply rising sandstone with a thin soil covering, and to the south it is rimmed by lower, fixed and deeply leached sand dunes lying over sandstone (Timms 1976). Since Redhead Lagoon is impounded between coastal dunes and country rock (sandstone), it is classified as a dune contact lake (Timms 1976).

A diverse array of vegetation communities are associated with Redhead Lagoon. There are five vegetation communities present in the study area (Figure 2).

1. Dry sclerophyll forest situated on the northern half of the lagoon on clayey soil, dominated by Blackbutt (*Eucalyptus pilularis*) and Red Bloodwood (*E.gummifera*), with a shrub layer dominated by a continuous cover of Prickly Moses (*Acacia ulicifolia*).

2. *Angophora/Banksia* associated located on the deeply leached sand of the stabilised 'perched' dunes to the south of the lagoon, dominated by Sydney Apple (*Angophora costata*) and Old Man Banksia (*Banksia serrata*). There is a sparse understorey of immature trees and minor species and a thick herb layer of up to one metre consisting of Bracken (*Pteridium esculentum*).

3. *Melaleuca* community in a narrow range (20 metres) around the perimeter of most of the lagoon. The dominant tree is exclusively Broad-leaved Paperbark (*Melaleuca quinquenervia*), although the continuity of this community is interrupted at several points around the lagoon due to clearing.

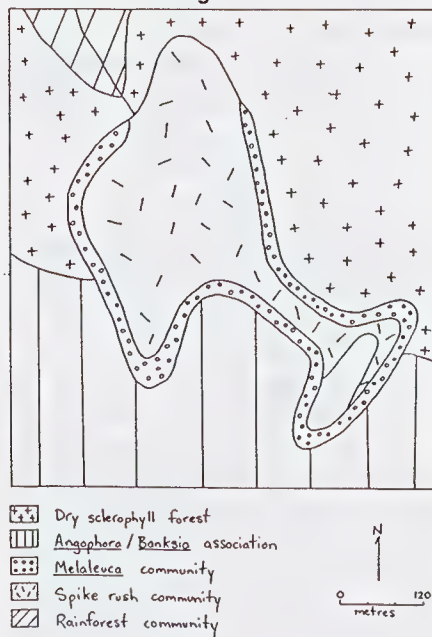
4. Spike rush community which occupies a large area of the eastern section of the lagoon, dominated by *Lepironia articulata* with small patches of Tall spike rush (*Eleocharis sphacelata*). The community has not become established in the central area of the eastern

section of the lagoon, presumably because the water here is too deep (2.2 metres).

5. Rainforest community which exists as a remnant patch along a small creek to the north-west of the lagoon. No overstorey is present and the understorey is dominated by Cheese Tree (*Glochidion ferdinandi*) and Lillipilly (*Acmena smithii*). The exotic species *Lantana camara* occurs in patches around the perimeter of this community, which is surrounded by cleared land.

Water hyacinth (*Eichhornia crassipes*), a noxious weed species, has infested much of the lagoon and was a dominant in the north of the western section of the lagoon at the time of the study.

**Figure 2. Dominant vegetation communities at Redhead Lagoon**



The average minimum temperature for the area is 6°C for July and the average maximum temperature is 30°C for January (Tweedie 1963).

## METHODS

The survey was conducted between mid-August and early December 1992. An addi-



tional survey was undertaken in mid-February 1996. Surveying was undertaken two to three nights per week and preference was given to sample on nights in which rain was falling. It is estimated that a total of 105 hours was spent sampling the study area over a period of 14 weeks.

Nocturnal sampling of the area was conducted using spotlighting methods and occurred between 1800 and 2300 hours. Diurnal opportunistic sampling involved the inspection of loose *Melaleuca* bark, rocks, debris and logs between 1000 and 1800 hours. All habitat types were sampled equally. Identification of species by call was used for both nocturnal and diurnal sampling. Weather conditions, including temperature and rainfall, were noted. The results of the number of individuals present was recorded in the following qualitative format:

1. low (<5 individuals observed at one time)
2. moderate (5-10 individuals observed at one time)
3. high (>10 individuals observed at one time)

## RESULTS

Twelve frog species, representing two families and six genera, were present in the study area. Relative abundance and activity data is presented in Table 1. Microhabitat preferences and habits for each of the species are noted in the species profiles.

### Hylidae

#### **Dwarf Tree Frog (*Litoria fallax*)**

Represented the most widespread and abundant hylid. One of the most consistent callers and was quite active during the day. Calling was recorded to take place from low vegetation such as from Bracken (*Pteridium esculentum*), grasses such as *Paspalum dilatatum* and the emergent *Lepironia articulata*, at a height of 0-0.5 metres. At night it could be found on this low vegetation in the habitats listed in Table 1.

#### **Freycinet's Frog (*Litoria freycineti*)**

Observed only during mid-February and not encountered in spring. This species was heard

calling amongst grasses (*Paspalum dilatatum*) in the *Melaleuca* community. Individuals were also found foraging in the late afternoon (1700 hours DST onwards) following rain in the *Melaleuca* community adjacent to the *Angophora/Banksia* association.

#### **Jervis Bay Tree Frog (*Litoria jervisiensis*)**

Most abundant in the spike rush community. Males were observed to call whilst perched on *Lepironia* and *Eleocharis* at water level, and foraging occurred at a height of 0-1.0 metre within stands of these reed species. One individual was found during the day in mid-August under the bark of a *Melaleuca*. It was not active on warmer nights when the temperature was above approximately 20°C and calling ceased during early October.

#### **Peron's Tree Frog (*Litoria peronii*)**

Calling was observed to commence in mid-September. Found predominantly in the *Melaleuca* branches overhanging *Lepironia* at a height of 1.0-3.0 metres. Individuals were located under the loose bark of *Melaleuca* during the day, usually at a height of 1.5 metres.

#### **Whirring Tree Frog (*Litoria revelata*)**

Initially encountered during heavy rain in mid-September foraging in the *Angophora/Banksia* association amongst Bracken (*Pteridium esculentum*) and Bladey Grass (*Imperata cylindrica*) at a distance of approximately 50 metres from the lagoon. This behaviour was recorded at 2000 hours EST and at a height of 0-0.3 metres. Calling was recorded from *Lepironia* at the edge of the lagoon at a height of 0-0.5 metres.

#### **Tyler's Tree Frog (*Litoria tyleri*)**

Abundance and habits of this species were seen to be similar to those of *Litoria peronii*, although *L. tyleri* was noticed to prefer to call from thickets of *Lepironia* at water level. This species could be heard calling during warm ( $T > 25^{\circ}\text{C}$ ) overcast days in mid-September, however such diurnal calling behaviour ceased in mid-October.



## **Myobatrachidae**

### **Tusked Frog (*Adelotus brevis*)**

Heard calling during the day at approximately 1500 hours DST amongst Water Hyacinth (*Eichhornia crassipes*) on the western fringe of the lagoon in a disturbed area of *Melaleuca* in low numbers. No foraging behaviour was recorded for this cryptic species.

### **Common Eastern Froglet (*Crinia signifera*)**

Calling was heard from thickets of grasses such as *Paspalum* at the edge of the lagoon and at all sampling times, both diurnal and nocturnal. A wide range of refugia was utilised by this species, especially the fallen bark of *Melaleuca*.

### **Eastern Banjo Frog (*Limnodasynastes dumerilii grayi*)**

Initially encountered during heavy rain in mid-September where it was observed moving from the *Angophora/Banksia* association towards the lagoon, presumably to commence breeding. Heard calling from debris and *Paspalum* at the edge of the lagoon.

### **Striped Marsh Frog (*Limnodynastes peronii*)**

Represented the most widespread, abundant and active myobatrachid. This species was the only frog to inhabit the areas infested with water hyacinth to any significant extent (ie. >10 individuals). Found sheltering under a wide variety of debris within the habitats recorded in Table 1 and active at all sampling times. Foraging was observed in the dry sclerophyll forest, the *Angophora/Banksia* association and the *Melaleuca* community.

### **Haswell's Frog (*Paracrinia haswelli*)**

Heard calling from grasses (*Paspalum dilatatum*) in the *Melaleuca* community and within stands of *Lepironia* during both the day and night. Predominantly found under the fallen bark of *Melaleuca* during the day. Foraging was recorded in the *Angophora/Banksia* association during September at 1900 hours EST on a wet night.

### **Gray's Toadlet (*Uperoleia laevis*)**

This cryptic species was heard calling under

debris, leaf litter and thickets of *Paspalum* at a depth estimated to be approximately 0.1 metres. Foraging activity was observed in the *Angophora/Banksia* association during September on a rainy night. Activity and habits of this species were seen to be similar to that of Haswell's Frog (*Paracrinia haswelli*).

## **DISCUSSION**

Comparison of the species composition of Redhead Lagoon to that of the other areas in the Hunter Region reveals that the twelve frog species present compares well with eleven for the Cooranbong area (Timms 1976) and Hexham Swamp (Markwell 1984), and fifteen for the Myall Lakes (Markwell and Knight 1986). The Myall Lakes survey covers a region of similar coastal physiography with Redhead Lagoon. Similarities include the area exists close to the sea, is situated behind a dune barrier complex and possesses three similar vegetation communities, these being *Melaleuca* swamp, *Angophora/Banksia* association and spike rush communities. In contrast, however, the Myall Lakes study area occurs at or near sea level.

The majority of the species encountered have a distribution which occurs in a narrow range between the Great Dividing Range and the New South Wales coast. There is generally a switch-over from the south coast fauna to north coast fauna around the coastal Hunter Valley (Mahony *pers. comm.*). Considering this, the frog faunal assemblage of Redhead Lagoon can be regarded to exist in a region of overlap between north and south coast anuran communities. For instance, the distribution of the predominantly south coast species *Paracrinia haswelli* diminishes in the central coast of New South Wales (Cogger 1992) and the most northerly recorded locality for this species is the Myall Lakes system (Markwell and Knight 1986). In comparison, the north coast species *Litoria revelata* is present. This hylid has been recorded from the central coast (Ourimbah) to the Richmond River (Mahony and Knowles 1994).

The incidence of winter breeding frog species such as *Litoria jervisiensis* can be related to the winter rainfall pattern under a maritime

influence and the close proximity of the lagoon to the sea which ensures that temperatures, on average, are never lower than 6°C (Tweedie 1963) and that the occurrence of frost is low, if at all. It would appear that such conditions would restrict this species to low altitudes and indeed, all recorded specimens have been collected away from the Great Dividing Range (White *et al* 1980). *Litoria jervisiensis* has been recorded along the coast of New South Wales from Twofold Bay in the south to Ballina in the north (White *et al* 1980) and exists in the central part of its range at Redhead Lagoon.

White *et al* (1980) record that the critical temperature of activity of *Litoria jervisiensis* seemed to be at a wet bulb reading of 6°C, where no calling by the males was heard below this. This study recorded a maximum temperature limit for calling in this species to be 20°C, above which calling ceased. Calling of this species has been reported to continue to mid-October (White *et al*, 1980), although activity ceased at Redhead Lagoon in early October. It could be suggested that the extension of the species range northwards is restricted due to the higher temperatures experienced in the far north coast of New South Wales. White *et al* (1980) suggest the unsuitability of terrain. It is evident from the data presented in the results that the highest relative abundance of frogs at Redhead Lagoon occurs within the *Melaleuca* community. This may be explained by the large variety of calling and refuge sites present along the perimeter of the lagoon in this community. Only one species was recorded from the small remnant of rainforest community (*Limnodynastes peronii*). Due to the limited amount of water available in the creek draining this community, it would appear that inadequate conditions exist for breeding.

The reed species *Lepironia articulata* was seen to be the preferred vegetation calling site for the species recorded in the spike rush community. Thickets of this emergent would appear to provide adequate cover and protection from predation for frogs utilising it for breeding purposes. Certain species (*Litoria*

*revelata* and *L. tyleri*) were recorded calling only from *Lepironia*. Other species (*Litoria jervisiensis*) would call from both *Eleocharis* and *Lepironia*. White *et al* (1980) record that the critical factor at sites containing *Litoria jervisiensis* is the presence of thick stands of emergent vegetation such as *Typha* and *Eleocharis*.

Timms (1976) has recorded that the introduced Mosquito fish (*Gambusia* sp. complex) is very common at Redhead Lagoon, although none were observed during the study period. This species is known to predate heavily upon the eggs and tadpoles of frogs (Barker and Grigg 1977) and, if still present, may have potentially decreased the suitability of the lagoon as frog habitat. However, considering the length of time which has elapsed since *Gambusia* was recorded by Timms (20 years), during which time the lagoon has completely dried out twice in drought periods in the early 1980's and has been subjected to fire (Timms *pers. comm.*), it is unlikely that this species has persisted since the 1970's. Timms (1976) suggests that the fauna of Redhead Lagoon was more diverse in its pristine state, before the introduction of *Gambusia*.

The prevalence of Water hyacinth (*Eichhornia crassipes*) is of concern since this noxious weed covers a large area of Redhead Lagoon and is known to reduce oxygen levels in the water it covers (Sainty and Jacobs 1981). One possible effect on frog populations may arise from the fact that tadpoles depend on higher dissolved oxygen levels in the water and this plant may limit the value of this area as a breeding site. Only two species, the Striped Marsh Frog (*Limnodynastes peronii*) and the Tusked Frog (*Adelotus brevis*) were recorded breeding in this area. *Limnodynastes peronii* was present in high numbers, though few individuals of *Adelotus brevis* were recorded.

It is hoped that the information presented in this survey report will assist the NSW National Parks and Wildlife Service in the management of Redhead Lagoon and be useful for longer term monitoring of frogs in the area, especially comparative studies. It is also anticipated



that the information will be useful for educational purposes at Awabakal Field Centre, Dudley, New South Wales.

## ACKNOWLEDGEMENTS

I would like to thank Frank Lemckert and Michael Mahony for critically reviewing the manuscript, and Gavin Ayre for field assistance.

\*The key for the habitat preferences is as follows:

1. Dry sclerophyll forest
2. *Angophora/Banksia* association
3. *Melaleuca* community
4. Spike rush community
5. Rainforest community

**Table 1.** Relative abundance and activity data collected during the study period. It can be seen that the *Melaleuca* community contains the greatest species abundance and diversity (11 of the 12 species recorded in the study area occur in this community).

Species	Habitat*					Month Calling					
	1	2	3	4	5	Aug	Sep	Oct	Nov	Dec	Feb
Hylidae											
<i>Litoria fallax</i>	low	low	high	high	-	-	+	+	+	+	+
<i>L. freycineti</i>	-	mod	high	-	-	-	-	-	-	-	+
<i>L. jervisiensis</i>	-	-	low	mod	-	+	+	+	-	-	-
<i>L. peronii</i>	-	-	mod	high	-	-	+	+	+	+	-
<i>L. revelata</i>	-	low	-	low	-	-	+	+	-	-	-
<i>L. tyleri</i>	-	-	low	high	-	-	+	+	+	+	-
Myobatrachidae											
<i>Adelotus brevis</i>	-	-	low	-	-	-	-	-	+	+	-
<i>Crinia signifera</i>	low	-	high	low	-	+	+	+	+	+	+
<i>Limnodynastes dumerilii grayi</i>	-	low	low	-	-	-	+	+	-	-	-
<i>L. peronii</i>	low	low	high	mod	low	+	+	+	+	+	+
<i>Paracrinia haswelli</i>	-	low	high	high	-	+	+	-	-	-	-
<i>Uperoleia laevigata</i>	low	low	high	mod	-	+	+	+	-	-	-

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## POSSIBLE OVERWINTERING ON LAND BY HATCHLING *CHELODINA LONGICOLLIS*

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Hatchling turtles of North America commonly overwinter in the nest and emerge in spring (e.g. Cagle, 1944; Hartweg, 1944; Sexton, 1957; Gibbons and Coker, 1977). However, it has been suggested that the relatively mild winters in Australia (compared with North America) would not necessitate this occurrence (Legler, 1960), and the studies of Parmenter (1976) on *Chelodina longicollis*, collected near Armidale (northern New South Wales), provided no evidence that juveniles overwintered in the nest, thus supporting Legler's (1960) hypothesis. Conversely, Chessman (1978), working in south-eastern Australia on the same species, suggested that hatchlings may overwinter in the nest. This conclusion was based on the observation that only one hatchling was collected during intensive autumn netting compared with six collected during spring netting. Kennerson (1980) also provided circumstantial evidence that hatchling *C. longicollis* may have overwintered in a nest, based on the discovery of five juveniles swimming within his outdoor enclosure in October. We present further evidence of overwintering in the nest of hatchling *C. longicollis*. In October 1995, after rain the previous week, four hatchling *C. longicollis* were collected from pitfall traps on the outside of a driftnet fence which encircled a dam on the University of Western Sydney - Hawkesbury campus (33°37', 150°45'). We hypothesise that these individuals had recently emerged from their nest after spending the winter there and we outline our reasoning below.

1. It was too early in the season for hatchlings to have emerged from eggs laid in spring since hatching generally occurs between March and May (Chessman, 1978), after an incubation period of (65 days, Legler and Georges, 1993).

2. The drift fence had been in place for 12 days and the hatchlings collected were on the outside of it, moving towards water and not away from it.

3. They were together as a 'pod' and no other hatchlings or small juveniles were found on land, despite systematic searches for them along the drift fence and in the pitfall traps, throughout the remainder of the Spring (1995) and Summer (1995-1996).

4. The sizes and weights of our hatchlings were similar to the limited published data on hatchlings (see Table 1). Although the egg sac had been partly resorbed, the central plastron scar had not healed, providing additional evidence that these individuals were newly emerged hatchlings.

5. Annual growth of *C. longicollis* in the Gippsland area has been documented at 35 mm carapace length each year in juveniles (Chessman, 1978) which agrees with our interpretation of the age of the turtles since, although our data are limited, we have observed that hatchlings grow rapidly during their first season.

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**Table 1:** Carapace length (cm) and weight (g) of hatchling *Chelodina longicollis*

Carapace length (cm)			Weight (g)			Reference
x	sd	range	x	sd	range	
2.51	0.07	2.43-2.59	3.04	0.22	2.73-3.33	<b>This study</b>
2.8						Armstrong, 1980
2.6 (smallest)						Chessman, 1978
2.5						Hill, 1979
			4.2	0.1	3.0-5.2	Kennett & Georges, 1990
2.75						Kennerson, 1980
3.0	1.7		4.6	0.5		Legler & Georges, 1993
2.96	0.018		4.53	0.88		Parmenter, 1976
		2.15-2.3				Vestjens, 1969
2.45						Wells, 1973

# THE BAITING OF PITFALL TRAPS WITH VEGETABLE OILS – ITS EFFECT ON THE CAPTURES OF HERPTILES IN A COASTAL LOWLAND COMMUNITY

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## ABSTRACT

Pit-trapping is generally not an efficient means by which to sample a significant component of the herptile fauna within a habitat. However, the method can be easily standardised from survey to survey (and is therefore useful as a monitoring system) and may capture rare or cryptic species that could otherwise go undetected. Any increase in the efficiency of a pit-trapping system is therefore desirable if it is to be used as a monitoring technique. To test if oil lures enhanced captures of species or individuals of any particular species, oil baits of different types were placed in pits on drift fence lines. There was no significant effect due to oil or oil type.

## INTRODUCTION

While there has been considerable investigation of the effect of different baits on the trapability of small mammals (Beer 1964; Patric 1970; McComb *et al* 1991; Du Toit and Fourie 1992), the use of baits or lures for pitfall trapping of herptiles has been mainly undocumented or untried. On the other hand the relative efficiencies of different pit-trap systems for sampling reptiles within Australian spinifex grasslands has been tested (e.g. Morton *et al* 1988).

To a large extent, the capture of herptiles in pit-traps connected by a drift fence relies on the chance occurrence of animals encountering the drift fence and following it until they fall into a pit. In effect then, drift fences block the movement of animals and lead to capture. However, baits or lures placed within pits may enhance captures by attracting animals directly to pits which are baited. Lures may draw animals to the scent of the bait itself or to insects and other prey also lured to the site. We sought to test whether attraction could be

detected, by examining the number of species and the numbers of captures within pits baited with different oil types and unbaited pits.

The experiment was undertaken in native vegetation, in an area dedicated to a study of the effects of prescribed burning (established in 1973) on fauna and flora, and occurred in conjunction with other studies of the effects of fire regimes on diversity and abundance of fauna (Hannah and Smith 1995).

## STUDY AREA

The study area is located 50 km north of Brisbane, in Scientific Purposes Area 1 (SPA1) due east of the township of Beerwah, south-east of Queensland (26°51'S, 152°59'E). The SPA1 is 13 km from the sea, approximately 32m altitude (Dwyer *et al*, 1978) and 624.2 ha in size. The vegetation types present in the SPA1 include heath and herblands, Scribbly Gum (*Eucalyptus signata*) forests, Scribbly gum/Bloodwood (*Eucalyptus intermedia*, *E.gummifera*, *E.trachyphloia*) associations and shrublands (Dwyer *et al*, 1978).

## METHODS

Pit-trapping was undertaken in two study blocks separated by 40 metres of heath. Each block consisted of three fire treatments, with each treatment approximately 1 hectare in area. Each block was surveyed consecutively for six days (11-16 January 1994 and 23-28 January 1994).

Vertebrates were sampled using pitfall trap lines, each line consisting of five pits connected by a drift fence. Pits were 400 mm deep by 240 mm diameter, placed in a line at five metre intervals. Drift fences were 300 mm high, of aluminium or nylon fly wire, passed through the centre of each pitfall trap, extending five metres beyond the first and last pit and



totalling 30 metres in length. Three lines were placed randomly within each of the three fire treatments in each block.

Oil baits or lures consisting of pieces of cardboard soaked in one of four oils were placed within pitfall traps. Vegetable oils included: linseed, safflower, sunflower, and sesame. Each oil was represented in a trap line, with the remaining pitfall being left unbaited (i.e. a 'no oil' control). The oils were randomised within trap lines using a random number table (Kenkel, 1984). Lures were placed in pits the night before commencement of surveying and replaced on the morning of each survey day. The experimental design was balanced across blocks, fire treatments and oil treatments. A total of 270 pitfall trapping nights were completed in each block. Pitfall traps were checked three times daily and species captured were released approximately 10m from their point of capture.

Nomenclature of herptiles followed Cogger (1992).

## RESULTS AND DISCUSSION

Standard monitoring techniques for amphibian and reptile diversity should be designed to capture as large a subset of the species within an area as possible. Monitoring should involve a number of techniques and each technique should be optimal. The efficiency of baits and lures for increasing capture rates in the pits of a pit-trapping system has therefore been addressed, where previously little data has been available.

A total of 233 captures consisting of eight species of reptiles and four species of amphibian (12 herptile species total) were made in pits (Table 1). Seven herptile species were recorded in each of the oil treatments and the control. These 7 species subsets, from the 12 recorded for pits as a whole, differed among treatments and the control.

Twenty species of herptile were recorded within the fire study blocks as a whole (combining records from pit-trapping, visual and aural searches; Hannah and Smith 1995). A further four species were detected in the SPA1, along

roads (Hannah and Smith unpublished data). Pits were effective in recording only approximately one half of the species present in the area. Pit-trapping did not record any species that were not recorded by either visual or aural means.

Chi-Squared tests (of a 1:1:1:1:1 hypothesis, i.e. an even distribution across treatments) were used to test the likelihood that oil treatment affected the numbers captured. The number of captures (all species combined) did not differ significantly among oil treatments or the control (data pooled from burning treatments and blocks:  $\chi^2 = 1.53$ , d.f. = 4,  $P > 0.05$ ). The most commonly caught species were *Crinia tinnula*, *Lampropholis delicata* and the introduced *Bufo marinus*. *C. tinnula* is listed as Vulnerable under Queensland's Nature Conservation Act 1994 (Q.DEH 1994). Three chi-squared tests examining for associations between each of these species and oil type (or no oil) were performed, but none was significant.

No oil appeared to act as a lure to the herptile community in general or to any one of the more common species. This does not discount the possibility that the efficiency of the pit trapping system as a whole may have been enhanced by oils, i.e. compared to a non-baited pit-trap system, and while this was not tested by the present study, it does require further investigation.

Although recent evidence suggests that pits are an inefficient means for capturing all amphibian species in an area, pit-trapping can provide a useful standardised method and is able to detect cryptic or rare species that may otherwise not be recorded by other techniques (Parris et al 1995; K. Parris, pers. comm.).

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Table 1:

Genus/Species	Linseed	Safflower	Sunflower	Sesame	No oil	Total
<b>BLOCK 1</b>						
<b>Reptiles</b>						
<i>Amphibolurus nobbi</i>	0	2	0	0	2	
<i>Diporiphora australis</i>	1	2	0	0	0	
<i>Ctenotus arcanus</i>	1	1	1	0	0	
<i>Lampropholis delicata</i>	3	3	3	5	8	
<i>Lygisaurus foliorum</i>	0	0	0	0	1	
<i>Demansia psammaphis</i>	0	0	1	0	0	
<b>TOTAL REPTILES</b>	<b>5</b>	<b>8</b>	<b>5</b>	<b>5</b>	<b>11</b>	<b>34</b>
<b>Amphibians</b>						
<i>Crinia tinnula</i>	10	10	2	10	7	
<i>Limnodynastes peronii</i>	0	0	0	1	0	
<i>Limnodynastes terraereginae</i>	1	2	0	0	1	
<i>Bufo marinus</i>	13	9	6	6	6	
<b>TOTAL AMPHIBIANS</b>	<b>24</b>	<b>21</b>	<b>8</b>	<b>17</b>	<b>14</b>	<b>84</b>

**BLOCK 2**

<b>Reptiles</b>						
<i>Ctenotus arcanus</i>	0	0	0	1	0	
<i>Haemaphysoderon gerrardii</i>	0	0	1	0	1	
<i>Lampropholis delicata</i>	3	3	0	1	1	
<i>Tiliqua scincoides</i>	1	0	0	0	0	
<b>TOTAL REPTILES</b>	<b>4</b>	<b>3</b>	<b>1</b>	<b>2</b>	<b>2</b>	<b>12</b>
<b>Amphibians</b>						
<i>Crinia tinnula</i>	14	12	22	10	8	
<i>Limnodynastes peronii</i>	0	0	0	1	0	
<i>Limnodynastes terraereginae</i>	2	1	2	1	1	
<i>Bufo marinus</i>	2	6	9	3	9	
<b>TOTAL AMPHIBIANS</b>	<b>18</b>	<b>19</b>	<b>33</b>	<b>15</b>	<b>18</b>	<b>103</b>

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# SUCCESSFUL BREEDING OF THE DIAMOND PYTHON (*MORELIA S. SPILOTA*) IN THE WET/DRY TROPICS OF NORTHERN AUSTRALIA

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The Diamond Python (*Morelia spilota spilota*) is a moderately large, brightly coloured python attaining a maximum length of 3 metres (Cogger, 1992; Slip and Shine, 1988d). This is one of the better researched of the Australian pythons with a number of studies including ecology (Slip and Shine, 1988 a,b,c,d,e), thermal biology (Ayers, 1992), digestive efficiency and metabolic rate (Bedford and Christian, unpub. data).

Few Australian records exist regarding the breeding of this sub-species outside the temperate region. A number of breeding records exist outside Australia, with offspring from captive animals being a matter of course in some U.S. collections (Barker and Barker, 1994). This note is of interest as it indicates that this animal can also be bred in the tropics. Two of three animals in this study were second generation captive bred. The female and one of the male pythons were hatched in February 1992, in Adelaide then sent to Darwin. The mass of the female in 1994, before oviposition, was 1200g and a snout-vent length of 1500mm. Although the length of this animal appears to concur with the average mature length proposed by Shine (1991), the mass of the python appeared to be less than expected for a reproductive animal of this species (Barker and Barker, 1994; P. Harlow, pers. comm.).

In the tropics I keep them in air-conditioning during the wet season (October – March), housed in large aquaria with heating lights at one end and a cardboard box for shelter at the other. This layout acts as a thermal gradient with pythons able to choose a temperature between 22°C and 45°C. They are housed in an outside animal house for the remainder of the year in large perspex boxes (56 litre) with

clipped on lids, and subject to ambient temperatures. Water is provided one day per week as it is my observation that excessive humidity may contribute to skin ulcerations if water is left continuously in the cage in an environment where humidity can be 90% for months at a time.

The temperature regime in the wet/dry tropics is markedly different to that which would be experienced by wild Diamond pythons in New South Wales. The tropical north around Darwin has a mean maximum temperature in the wet and dry of 33.1°C and 30.4°C respectively (Darwin Meteorological Bureau, 1993), and the mean minimum temperatures are 25.3°C and 19.3°C respectively. It is unknown what stimulates pythons to breed, some authors have proposed temperature, while others argue humidity, photoperiod or a combination of many physical attributes (Field, 1990; Shine, 1991; Barker and Barker, 1994). When considering reproductive stimuli it would appear that Darwin does not exhibit the same degree of annual variation in temperature when compared to the thermal properties of the Sydney region (see Slip and Shine, 1988 a,b,c,d for profile). Similarly being close to the equator, Darwin experiences little seasonal variation in hours of sunshine from summer to winter solstice.

Two males were placed in the cage with the female in mid September 1994. No mating was observed and the males were only placed in the female's cage for about four days. Only the two males were used. One, as mentioned, was a sibling to the female, the other was unrelated.

Oviposition occurred on Tuesday December 13, 1994. Ten fertile and five infertile eggs were laid. Mass of one fertile egg was 18

grams, one infertile egg weighed 10 grams. The fertile eggs were adhered to the paper substrate and only one egg could be removed from the paper for fear of harm to the developing embryos. This egg was measured, subsequent data could only be extrapolations from this so little data is presented. For this reason relative clutch mass (RCM) was not determined or compared to the data presented by Barker and Barker (1994).

Many gravid pythons in the latter stages of egg development lie with their ventral surface exposed (Barker and Barker, 1994), a behaviour observed in this Diamond python. The snake shed 28 days prior to laying which is considerably longer than the previously reported range of 21-25 days (Barker and Barker, 1994).

Eggs were placed in plastic containers filled with 190ml of water and 200g of vermiculite which were sealed with a plastic film (Glad Wrap). A water potential of -300kPa using the formula of Tracy *et al* (1978) was obtained. They were incubated in a thermoline incubator at a constant temperature of 30.0°C. Small holes were made in the plastic lid to give some air flow but limited water loss. The mass of the container with eggs was measured and this weight was maintained throughout incubation. Water was added using a pipette once per week. Hatchlings began emerging on Wednesday the 8th February, 1995. When the first egg had pipped, the rest were slit with a

scalpel as described by De Vosjoli *et al.* (1994). All ten animals hatched, however, one animal died shortly afterward. Mass and snout-vent lengths are given below (Table 1). Hatchlings were sexed by 'popping' as described by De Vosjoli *et al.* (1994) and Barker and Barker (1994). It was determined that there were six female and three male pythons. Two of the animals had no control of the tongue. The tongue was in place, but it appeared there was no muscular control of it. It is not known whether this defect is a result of incubation conditions or a genetic problem. All hatchlings fed voluntarily after the first shed. Six were fed live house geckos (*Hemidactylus frenatus*), which were caught around buildings in Darwin. The other three readily accepted pink mice. The parents of these hatchlings were fed house geckos as hatchlings with no parasitic effects having been evident over the past three years.

It is interesting that this species can be bred when only 30 months of age for females, although I am led to believe this is a common occurrence in the United States of America (Barker, pers. comm.). It is possible that because the animals in this case are captive bred, they have bred so readily. Many people keep this taxon in captivity but of the 427 carpet/diamond pythons kept in captivity by 152 people in South Australia only 10 hatchlings were bred in 1994 (SAHG Newsletter 88, 1995). This equates to one small clutch of

**Table 1. Mass and Snout-vent length of hatchlings.**

Diamond python	sex	snout vent length	mass (grams)
1	Female	356 mm	15.4
2	Female	360 mm	17.0
3	Female	360 mm	16.7
4	Female	350 mm	17.0
5	Female	385 mm	17.3
6	Female	370 mm	16.7
7	Male	375 mm	16.7
8	Male	320 mm	13.5
9	Male	365 mm	16.5



eggs, it is unknown which taxa was responsible. Through captive breeding programs in Australia, such as outlined here, it is hoped that more species of reptile can be bred in places exotic to their known geographic distribution. Breeding exotic animals is so commonplace in the USA that it rarely rates a mention (Barker, pers. comm.), but many obstacles prevent even pairing animals in Australia.

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# THE DUGITE OR SPOTTED BROWN SNAKE

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### INTRODUCTION

*Pseudonaja affinis affinis* (Gunther, 1872) is a very common elapid snake in the highly populated south-west of Western Australia. As is the case with many of the common species in this state little published data is available on it and even less on the insular subspecies, *exilis* (Storr, 1989) and *tanneri* (Worrell, 1961). Storr *et al* (1986) included *inframacula* (Waite, 1925) as a subspecies also, however we have followed Cogger (1994), Ehmann (1992) and Mengden (1985), all of whom consider *inframacula* a full species. Here we review all available literature and include both published and previously unpublished information on the morphology, colour variability, distribution, habitat, size, growth, longevity, reproduction, seasonality and prey of the dugite.

### MORPHOLOGY & COLOUR VARIABILITY

A large slender to moderately stout snake: young individuals tend to be quite slender while older snakes are usually stouter. This is consistent with their foraging behaviour: young snakes actively hunt lizards while adults tend to feed on mammals. Mammals are often in burrows or similarly restricted places where a slender form for speed and agility is of less benefit than the strength of a stout body.

Body matt to moderately glossy. Midbody scale rows 19 (rarely 17 or 18). Anal scale divided, rarely undivided. Subcaudals divided; however a few undivided subcaudals are common. Scale abnormalities occur in most snakes, particularly when examining a large series of the one species. Annable (1985) recorded subcaudal scale anomalies in *P. textilis*. Osgood (1978) stated that extreme temperature during incubation often resulted in

scale abnormalities.

The range of ventrals and subcaudals are subspecies specific. The insular subspecies have smaller ranges and lower maxima than the mainland subspecies; i.e. *P.a. affinis* 203-242, 48-66 (Storr *et al*, 1986 & pers. obs. N=27v, 32s); *P.a. exilis* 207-219, 48-57 (Storr, 1989 N=16); *P.a. tanneri* 201-216, 56-60 (Worrell, 1961 N=7 & pers. obs. N=2). Two juvenile *P.a. affinis* from the Perth suburb of Canning Vale had unusually low ventral counts of 142 and 156. Collected within a week of each other they are possibly siblings.

Residents of the south-west popularly consider the dugite to be a plain brown snake. When observing *P.a. affinis* other than brown, they refer to them by different names, i.e. mungi snake, grass snake, sand snake, etc. Although it is a member of the 'brownsnake' genus, like its congener *nuchalis*, it displays considerable variation in colour and pattern. The following authors have generally simplified this in their respective descriptions: Cogger, 1994; Ehmann, 1992; Glauert, 1950; Gow, 1982; Storr, 1979 and Storr *et al*, 1986. Cogger (1994) may have mistakenly described *nuchalis* when referring to an inverted 'V' or 'W' on the nape in some *affinis*. We have never observed this pattern in any Western Australian *Pseudonaja* other than *nuchalis*. Wilson and Knowles (1988) mention how variable the colour is but do not attempt to illustrate this by describing 'morphs'. Chapman (1995) describes typical *affinis* similar to Plate 15 (2) in Storr *et al* (1986) and smaller very dark individuals that were presumably *Pseudonaja* from the Fitzgerald area on the south coast. Bush (1981) was aware of the diversity in this species and defined several morphs, i.e. brown, black, mottled and yellow. The monotonal, banded and dual banded



morphs described here later are convergent with *nuchalis*.

Dugites maintained in captivity darken with age, while those with spots have a corresponding increase in the density of these. Orange (1992) observed the dorsal colour darkening to black on two separate occasions in captive-raised *P.a. affinis*.

Adults of the insular subspecies, *P.a. exilis* and *P.a. tanneri*, are immaculate chestnut brown to black above. The belly ranges from marginally lighter than the dorsum to immaculate black. Worrell (1961), in his description of *P.a. tanneri* from Boxer Island, states some indistinct dark blotches at the posterior edge of the ventrals ventrolaterally and distributed over most of ventral surface. Specimens from Figure of Eight Island range from that described by Worrell to immaculate gunmetal blue or black on the belly.

We find the only satisfactory way to describe colour and pattern in *P.a. affinis* is to partition the consistent forms and describe them as morphs, as follows:

- a) **Monotonal** (Fig. 1) - upper surface uniform cream, yellow, brown, olive, green, brick-red, grey or black; no colour differentiation of head. The paler monotonal forms with or without herringbone pattern.
- b) **Sparsely spotted** (Fig. 2) - upper surface sparsely spotted and blotched with black. The spots vary in size from as small as a portion of a scale to as large as several scales. Ground colour pale cream, yellow, brown, green, grey or brick-red.
- c) **Densely spotted** (Fig. 3) - upper surface densely spotted and blotched with black. The spots vary in size as in the previous morph but density is so great in some as to cause a 'mottled' appearance. Dense spotting only occurs in larger and heavily bodied individuals, hence the density of the spots is age related. Glauert (1950) refers to this form by the aboriginal name 'kabarda'.
- d) **Pale head, grey nape** (Fig. 4) - upper body and tail monotonal yellow, brown or green with a much paler head (almost white in

some individuals) and darker neck band 10 or more scales wide. This morph is most prevalent in the Darling Range.

e) **Banded** (Fig. 5) - up to 15 strongly to weakly defined broad, dark bands; the widest bands occur on those individuals with the fewest neonatal bands and vice versa. Ground colour cream, yellow, brown or green. This morph is not abundant and is only marginally more common than the 'dual banded' morph.

f) **Dual banded** (Fig. 6) - upper body and tail with 9-15 strongly to weakly defined broad, dark bands. The interspaces with 3-5 narrow (1-1.5 scales wide) evenly spaced ragged bands caused by a transversely aligned darkening of the anterior and (to a lesser extent) posterior margins of dorsal scales. This pattern is almost identical to Mengden's (1985) *P.nuchalis* 'carinata' morph. In many individuals this patterning is only obvious when the snake inflates its body. With age the anterior bands fade being replaced by sparse spots. Ground colour yellow, brown or green. We consider this to be the rarest morph.

Ventrally there is also a large degree of variation often correlating with the morphs described above. The paler snakes tend to vary from pale cream, yellow or green with dark, random spots. These spots are most obvious anteriorly. The very dark and black individuals may have heavily mottled or blotched blackish variegations and these may coalesce into a uniform dark grey to black belly in some. This condition is typical in adult *P.a. exilis* and *P.a. tanneri*. Often the dorsal pattern extends onto the margins of ventrals and where these are wide may be broken medially (Storr *et al*, 1986).

Juveniles, with or without bands, are olive-green, yellow or brown with a uniform herringbone pattern, caused by dark (in descending order of frequency) lower anterior, lower posterior, upper anterior and upper posterior margins of dorsal and lateral scales. Upper parts of the head are matt black extending onto the neck for 6-15 scales. This may be a single large, black blotch or divided into a separate

head blotch and neck collar. In *P.a. exilis* and *P.a. tanneri* the dorsum is pale brown and there is a rapid ontogenetic spread over the remainder of each scale by the dark pigment responsible for the herringbone pattern. The bands in many *P.a. affinis*, when present, are most obvious in juveniles, becoming faded in adults. The belly in very young juveniles of all subspecies is usually pale with numerous spots. These may be darker or paler than surrounding colour. In both insular subspecies there is an ontogenetic darkening of the belly corresponding with that occurring dorsally.

## DISTRIBUTION AND HABITAT

**Distribution** - *Pseudonaja affinis* is widespread throughout south-western Australia. See Figure 7 for its known distribution. Longmore (1986) suggests *P.a. affinis* is sparse on the Nullarbor Plain in both W.A. and S.A. however this may reflect poor sampling. Greg Harold's observations (pers. comm.) suggest it is common near Eucla. On 3 September 1983 one of us collected four brown snakes on the Nullarbor. Two *P.a. affinis* (19 midbodies) from 5km west of Mundrabilla Roadhouse (WAM R85118) and 17km east of the WA/SA border, and two *P.inframacula* (17 midbodies) from 60km west of the Nullarbor Roadhouse (R85111) and 5km east of that roadhouse (R85110). On 8 April 1987 he also liberated two *P.a. affinis* from a concrete-lined well at the old Madura homestead. The Nullarbor *P.a. affinis* were dark to rich brown with sparse dorsal spotting and orange belly, whereas the two specimens of *P.inframacula* were almost black, lacked dorsal spotting, and had immaculate lead-grey to black bellies. Mark Hutchinson (pers. comm.) has advised us that only one South Australian record of *P.a. affinis* (SAM R26268) is in the SA Museum. Identified on the midbodies and belly colour as above, it was collected on 12 September 1994 from 10km north-east of Border Village. The only two confirmed records from SA suggest it is restricted to the extreme south-west of that State. Mengden (1985) illustrates a *Pseudonaja* from Penong,

South Australia that resembles our densely spotted morph of *P.a. affinis*.

The northerly-most *P.a. affinis* we have observed in WA were from Lancelin on the west coast and near Southern Cross to the east, and Paul Orange (pers. comm.) has recorded road-kills near Widgiemooltha. Where the range of *P.a. affinis* overlaps that of *P.nuchalis* in the central wheatbelt and southern goldfields regions, the former is much less common. Western Australian Museum records of *P.nuchalis* from the central wheatbelt are more than double the number of *P.a. affinis* from the same area (Chapman & Dell, 1985). Confined to Rottnest Island (1625 ha), about 20km west of Fremantle, is the subspecies *exilis*. The other subspecies, *tanneri* occurs on Boxer (192 ha) and Figure of Eight Islands (283 ha), 25-30km from Esperance, in the Recherche Archipelago. These are the only insular records for this species.

**Habitat** - *P.a. affinis* occupies virtually all habitats, including coastal dunes, semi-arid woodlands, shrublands and wet sclerophyll forests (Wilson & Knowles, 1988). It is also found in coastal and inland plains, slopes and ranges, especially in areas with sandy soil such as sandplains and coastal dunes. It occurs in vegetation of shrubland (including heath), woodland (including mallee) and sclerophyll forest (Ehmann, 1992). A reflection of its preference for dry sandy areas is its scarcity around wetlands, swamps and other extensive damp habitats. It is also uncommon in closed forests. Like its congeners, *nuchalis* (some populations) and *textilis*, it displays a strong predilection for disturbed habitats such as industrial areas, golf courses, road verges; etc. in close association with agricultural development (Shine, 1989). Its apparent success in these areas is indicative of its ecological tolerance. Its numbers appear to have greatly increased due to our modification to the land and especially to the introduction of the main constituent in the diet of the adults: the feral house mouse (*Mus musculus*). No other large reptile, or terrestrial vertebrate for



that matter, is as widespread and abundant in metropolitan Perth as the dugite. This ecological shift has occurred in the past century in Australia because of European settlement and agriculture. Storr *et al* (1978) noted an analogous pattern of abundance: 'Relatively low population densities in undisturbed bushland remote from settlement, increasing densities as settlement approaches, decreasing densities from the beginning of development to local extinction as area becomes completely built up.' Our observations support this. We have recorded large numbers of *P.a. affinis* in habitats altered by humans but rarely come across it in undisturbed bushland. Maryan (1993) made 112 separate observations of this species during an extended survey in some southern suburbs of Perth. Bush (1995), in a five year period to 1995, removed 119 individuals from yards and dwellings in the Midland area. These metropolitan regions are extensively developed for residential and semi-rural use.

Areas combining both remnant bushland and cleared land contain the highest concentrations of *P.a. affinis* on the mainland. Favourable areas where we have found this species in abundance are human-made grasslands around sheds and rubbish strewn areas. In the Perth area one of the dominant introduced grass species is the annual veldt grass (*Enrharta calycina*) which, during the warmer months, forms a low dense covering over the ground. In suitable habitats where mice are abundant, population densities of the snakes can be very high. In these areas we have found 5-7 adults within an area of less than 100m<sup>2</sup>. Its ability to persist and avoid detection in developed, densely populated areas is amazing, particularly for a large nomadic foraging elapid. Occurrences within the inner suburbs are infrequent however and there is usually a patch of remnant bush or an undeveloped housing block nearby; snakes inhabiting these briefly advance into backyards in search of mice. One gets the impression that they know every bird aviary, chook

run and old shed within their area, and visit each in turn before moving back to the bush. Robert Browne-Cooper (pers. comm.) has suggested these 'urban dugites' tolerate some close encounters with people for the sake of a good food supply and adequate shelter.

Elsewhere the density of *P.a. affinis* appears greatest in coastal areas that include rock formations (usually granite and limestone in the south-west) and undulating dunes with low heath including medium sized shrubs such as *Acacia* spp. The coastal areas that remain relatively undisturbed usually contain some evidence of human habitation such as camp sites and holiday shacks. There is an apparent increase in the number of *P.a. affinis* near these.

Both juveniles and adults are extremely opportunistic in choice of shelter sites. We have recorded them beneath and within logs and under rocks, concrete slabs, plastic sheeting, cardboard, corrugated iron, car bodies, tyres, fibro sheeting, animal carcasses, rolls of poly-pipe, etc. We have also unearthed them from grader spoil-heaps, abandoned termite mounds and stick-ant nests, as well as inside rodent, rabbit and lizard burrows. Bush (1981) lists a few shelter sites and succinctly states, 'anywhere else it can squeeze'. We have found it most often in disturbed areas beneath corrugated iron or similar; usually surrounded by dense grass that provides an ideal escape route for the snake when disturbed. Mice are also abundant at these sites and *P.a. affinis* will retreat down the mice's burrows to both avoid capture and overheating during summer. We have excavated torpid individuals from burrows during winter.

*P.a. exilis*, like its mainland counterpart, has probably increased in numbers due to human alteration of the island habitat and introduction of the house mouse. The vegetation has changed considerably since settlement with an increase in fires and grazing by the quokka, *Setonix brachyurus* (Anon, 1983). Rottnest Island had an almost impenetrable low closed forest that has gradually become dominated

by an *Acacia* species. Today its topography consists of undulating sand hills with a low coastal heath of varying densities and numerous limestone exposures. Considering the island's size, degree of disturbance, human settlement (concentrated at the eastern end) and thousands of visitors monthly, *P.a. exilis* is very common. We have found juveniles and adults beneath limestone rocks, deadfall vegetation, sheet and corrugated iron and other discarded rubbish. In September 1990 we found five adults, including a mating pair beneath corrugated iron at the one site. During spring (especially) and summer it is active on roads, tracks and amongst vegetation. One of us has seen adults basking on piles of seaweed on the beaches, eluding capture by entering the labyrinth within the tangled kelp. These piles of seaweed were usually situated from a few to several metres across bare sand to the nearest covering of limestone rocks and vegetation.

*P.a. tanneri* occurs on two relatively remote, undisturbed and uninhabited islands in the Recherche Archipelago. The habitat on Boxer and Figure of Eight Islands is mainly low dense heath with varying densities of *Acacia* spp. and extensive granite outcrops. These outcrops are a prominent feature of the islands. On Boxer Island there is also considerable patches of coastal limestone. The areas of vegetation most exposed to the elements become more open and wind-pruned. David Knowles visited Figure of Eight Island on 26 October 1994 and provided the following observations of *P.a. tanneri* on that island. 'I observed nine adults active on a large rocky outcrop with two of these being males involved in combat. The adult snakes shelter beneath the exfoliated rock and down crevices. I also uncovered four juveniles beneath a single granite slab embedded in the soil away from the outcrop'.

Mark Fitzgerald and Greg Mengden visited Boxer Island on 25 September 1981. Mark has provided the following observations of *P.a. tanneri* on that island. 'There were three dis-

tinct vegetation zones. The first was a low tangled mat of succulents and shrubs at the littoral edge; a mid-zone of surface limestone and waist-high shrubs with numerous runways made by Cape Barron geese; the third zone was up a rise where small wattles dominated below two or three limestone ridges outcropping across the island. In the more sheltered parts the *Acacia* spp. were 4-6 metres high with grass beneath. All the *P.a. tanneri* were located in the mid-zone. We did not observe any until mid-morning when they were located basking and later moving amongst the limestone. When pursued, they attempted to escape into the low vegetation or cracks in the rock. By midday it was quite warm and no more snakes were seen. Later in the afternoon we began to see the odd one moving. All were docile for *Pseudonaja* and were caught without demonstrating the defensive displays and striking behaviour of *P.a. affinis*. We saw eleven specimens ranging from 60-130 cm total length. All were a dark chocolate-brown to black dorsally with large dark blotches ventrally'.

The numbers recorded on respective one-day visits by David Knowles and Mark Fitzgerald suggest it is common. There is ample shelter and food, and predators are few on these islands. Two other elapids inhabiting islands in this archipelago are the death adder (*Acanthopis antarcticus*) and the crowned snake (*Drysdalia coronata*). Both are very common on some of the islands.

### SIZE, GROWTH AND LONGEVITY

**Size** - *P.a. affinis* is a large subspecies, reaching 213 cm total length. A very large male dugite displayed at the Perth zoo until its death in December 1992 measured 212.5 cm. It arrived at the zoo on 2 November 1980 as an adult of 135 cm. There is no record of the locality it came from but probably Perth. Large individuals occasionally occur in the metropolitan area. However consistently larger snakes occur in the southern coastal farming areas between Albany and Israelite Bay. Sightings of large dugites on the coast west of Esperance



are common. Three roadkills recorded by one of us near Lort River measured 200 cm total length. The average adult snout-vent length (SVL), when excluding individuals less than 60 cm and including both sexes in the sample, is 111.8 cm (60-184.5; N=95). The largest snakes measured were males, however no sexual size demorphism was indicated in the means recorded, males 111.8 (62.5-184.5; N=81), females 112.3 (70-140; N=14). Shine (1989) found little difference in the adult size also, i.e. males 108.5 (58.1-163; N=49), females 108.8 (74.6-149; N=35). He recorded larger adult males in *P.inframacula*, *P.nuchalis* and *P.textilis* and suggests (1978) this has evolved as a result of male-male combat. In the remaining three species, *P.guttata*, *P.ingrami* and *P.modesta* the females get marginally larger. The adult size recorded here is a little greater than in Shine (1989). A factor contributing to this would be the inclusion of the smaller *P.a. exilis* in his sample. This subspecies was not described when Shine did his dissections. His sample did include nine *P.a. exilis* (G. Shea, pers. comm.). According to Storr (1989) this subspecies has an SVL range of 22.3 cm to a maximum of 100.5 cm. Smaller still is *P.a. tanneri*. We have recorded a maximum SVL of 85.9 cm (TL 100) in this subspecies.

Neonatal SVL in *P.a. affinis* is 19.4-22.6 cm and weight 4.75-6.82g (Bush, 1992 & pers. obs.); the mean SVL and weight respectively based on 60 neonates from 3 clutches is 21.4 cm and 5.92g. The smallest wild caught juvenile measured 24.2 cm.

**Growth** - Shine (1989) reports the minimum size of adult *P.a. affinis* as males 58.1 cm and females 74.6 cm. Sexual maturity is probably attained at 18-24 months. Although we have not maintained neonatal *P.affinis* to adulthood, we have maintained large numbers of *P.nuchalis* from neonates to adults. Females are reproductively mature as young as 17 months or as small as 68cm SVL. Male *P.a. affinis* display sexual activity from as small as 50 cm but may not necessarily be sexually

mature at this size. Worrell (1961) reports observing *P.a. tanneri* as small as 70 cm copulating.

A partial indicator of growth is the frequency of sloughing. This is based on our numerous records of a progressive decline in sloughing frequency relative to a reduction in growth in the snakes we keep. Juvenile snakes given plenty of food have sloughed initially every 18-24 days. It is so often that there appears to be only time for a quick feed before going into pre-slough condition again. At 6 months of age the frequency has reduced to about 30 day intervals and progressively decreases to as few as 3-6 times each year. The old snakes continue to slough regularly e.g., a male collected in 1980, 15 years ago, sloughs at 2-2.5 monthly intervals. During the past 5 years it has averaged 5.2/year. Another four adult males have a mean of 3.25/year.

**Longevity** - There is little data on longevity in Australian reptiles and frogs. Currently there are a few long-term captive dugites in Western Australia. They are all alive at the time of writing (July 1996) except for one kept at the Perth Zoo from 1980 to 1992 and mentioned above. We have 3 males collected on the Esperance sandplain in 1979, 1980 and 1983. They were all guesstimated at 110 cm SVL when collected and in January 1996 measure 173, 165 and 157 respectively. These snakes could not have been any less than 3 years old when obtained. Therefore a conservative estimate of their age is 16-20 years; it is quite probable that *P.affinis* may live for 30 years.

## REPRODUCTION AND SEASONALITY

**Reproduction** - *P.affinis* is oviparous with the nominal race producing clutches of 11-35 eggs (mean 21, N=13) (data from Bush, 1992 and personal records of Brian Barnett, Brian Bush, Klaas Gaikhorst, Brad Maryan, Roy Pails and Rico Schmidiger). Shine (1989) recorded 3-25 eggs (14.5, N=11), however his sample may have included at least one of the smaller insular subspecies. We have no reproductive data on either insular race. However, we would expect these to have lower fecundities



**Figure 1** Monotonal adult. Clarkson, Perth suburb. Photo: B. Maryan



**Figure 2** Sparsely spotted adult. Swan view, Perth suburb. Photo: B. Maryan



**Figure 3** Densely spotted adult. Lort River near Esperance. Photo: B. Bush





**Figure 4** Pale head, grey nape adult. City Beach, Perth suburb. Photo: R. Browne-Cooper



**Figure 5** Banded adult. Lort River near Esperance. Photo: B. Bush



**Figure 6** Dual banded sub-adult. Kalamunda, Perth suburb. Photo: P. Orange.

relative to their smaller size. A 108 cm SVL captive mainland dugite inseminated on 28 July deposited 13 healthy eggs 46 days later. The reproductive effort of the female (clutch mass as a percentage of female mass immediately post-parturition) was 37%. This is quite low when compared to its congener *P.nuchalis*, 44.2-82.8% (mean 61.8, N=11). Also, from a single mating *P.nuchalis* can produce two clutches of eggs 43-65 days apart (Bush, 1994), but there are no records of this double clutching in *P.affinis* or any other *Pseudonaja*. However, we still believe it may occur in *P.affinis* (Bush *et al*, 1995). Shine (1989) suggests it may occur in *P.textilis* because of the long period (Oct-Jan) in which he recorded oviductal eggs in females.

Based on data in wild-caught gravid females, oviposition occurs from mid-December to the end of January. Egg size (mm) in seven clutches was, length 25-46, width 15-25 and mass (g) 4.6-13.9. Respective means for clutches we have recorded are 30.5 x 16.5 mm, 6.1g (N=4 of 16), 30.2 x 20mm, 6.33g (N=23), 32.4 x 19.5mm, 7.92g (N=20), 37.9 x 21.5mm, 11.35g (N=13), and from Bush (1992): 29.4 x 20.9mm, 7.3g (N=27), 40.7 x 19.7mm, 9.4g (N=11) and 40 x 22mm, 11.1g (N=13). Incubation periods are 91 days at 28°C, and from Bush (1992): 53-61 days at 30°C and 105 days at 23°C. Hatchling SVL (mm) is 194-226 (mean 214, N=60) and weight (g) 3.63-6.9 (5.92, N=62).

Male/male combat has been observed in October in the wild and from August to December in captivity. For a photograph of combat in *P.a. affinis* see Shine (1991: 65). We assume mating in the wild occurs during the corresponding period. In captivity mating will occur throughout the year in heated snakes. Copulation causes bleeding in females resulting in a considerable bloody fluid residue on the floor of the terrarium as an indicator of the event. We have not observed multiple matings in the dugite; after the initial copulation further attempts by the male to repeat this are unsuccessful.

**Seasonality** - Figure 8 illustrates comparative monthly captures for a) total sample excluding juveniles, b) adult females, c) adult males and d) juveniles. The mainland dugite displays the seasonality of captures generally expected in a snake exposed to warm summers and cool winters. Apart from juveniles we recorded almost nil captures in winter (one record for August or 0.9% of sample) and had the highest number in late spring (November 27%).

When we individually examine the sexes we find there is a skewed commencement of activity after winter. The males display much activity in October. Male/male combat occurs at this time in the wild, however females do not appear to be active. Maybe the snakes locate and inseminate females before the latter become active. Once inseminated, they hunt vigorously throughout November to lay down, in a very short time, the required nutrients for the embryos. Female *Pseudonaja* in captivity, and not intimidated by their keeper, eat very large amounts of food after mating (Bush, 1994). A captive female *P.a. affinis* weighing 309g when inseminated on the 28th July weighed 580g only 27 days later, at which time she finally refused a feed and went into a pre-egg-laying pre-slough condition. Related to this increased need to hunt is the peak in female captures in November. The total captures for the remainder of the year only just exceed the number for that month alone.

In summary: i) males begin moving earlier in spring and are generally active throughout the warmer months; and ii) females, after mating, are very active for a brief time in late spring and then do not move much at all for the remainder of the warmer months. The juveniles are most active immediately after hatching with a peak in March. This flurry of activity appears to be a result of their rapid dispersal from the hatching site.

## PREY

*P.affinis* is an opportunistic foraging hunter as described by Fearn (1994) for *Austrelaps superbus* in Tasmania. We have observed adult *P.affinis* investigating holes, crevices,



grass tussocks and surface debris for prey. This hunting strategy is typical of most of the large Australian elapids with the exception of the death adders (*Acanthophis* spp.). Apart from the limitations of prey size being dependent on the snake's size, the dugite feeds on all mammals and lizards without apparent selectivity. Juvenile and subadults feed primarily on the smaller lizards and baby mammals of the smaller species, while the adults take the larger lizards and mature mammals of the larger species. The diets of the larger *Pseudonaja* spp. are generally similar (Shine, 1989).

Various authors list small mammals, lizards, frogs, birds and occasionally snakes as the prey taken by *Paffinis* (Bush, 1981; Ehmann, 1992; Garnet, 1981; Gow, 1989; Mengden & Fitzgerald, 1987; Mirtschin & Davis, 1992; Storr, 1979; Sutherland, 1981 and Wilson & Knowles, 1988). Shine (1989) recorded 101 prey items in the stomachs of 68 *affinis*. They were birds 1, snakes 1, frogs 2, lizards 46 and mammals 49. Of the latter, 46 were exotic mice.

We have attempted to feed *P.a. affinis* the slender tree frog (*Litoria adelaidensis*) in captivity. A snake would grab the moving frog and immediately release it again when the inner parts of its mouth contacted the frog. It would appear the secretions on the frog's skin were unpleasant to the snake.

Before the introduction of the house mouse, *P.a. affinis* occurred in a region inhabited by numerous small native mammals in the families *Dasyuridae*, *Muridae* and *Peramelidae* (Storr, 1989). The high number of exotic mice recorded by Shine (1989) suggests the majority of his sample of snakes came from human disturbed areas where they are most common, such as the Perth metropolitan area. We expect *P.a. affinis* in areas isolated from development to feed more on native mammals.

We have noted the prey eaten by adult *P.a. affinis* after examining both human- and road-killed snakes, regurgitated remains and opportunistically observing feeding in progress

during snake removal calls and field work. Reptiles recorded are the bobtail (*Tiliqua rugosa*), ornate dragon (*Ctenophorus ornatus*) and bardick (*Echiopsis curta*). A road-killed male of 145.5cm SVL from Perth contained two adult bobtails (Robert Browne-Cooper, pers. comm.). The only birds recorded were quail regurgitated by snakes removed from backyard aviaries. These may have been mistaken for mice. The only native mammal taken was a southern brown bandicoot (*Isodon obesulus*). All other prey recorded were house mice.

Juvenile *P.affinis* feed primarily on small, diurnal lizards and occasionally nocturnal species. It is possible, from experience with immature snakes in captivity, that they also take 'pinkie' mice.

No stomach contents analysis has been done to date on the two insular subspecies. Therefore the following relates to the prey available to *P.a. exilis* and *P.a. tanneri*. Juvenile and adult *exilis* probably feed on all fifteen species of lizard (Bush *et al*, 1995) known to occur on Rottnest Island. Apart from the recently introduced *Mus* (Storr, 1989) and black rat, *Rattus rattus* (A. Burbidge, pers. comm.) there are no small native mammals on the island. Like their mainland counterparts, we would expect the adults to take mice also. Boxer and Figure of Eight Islands have four and three lizard species respectively (WA Museum, unpubl. notes). Lizard densities on both islands are high and, as there are no recorded native mammals, we suspect that *tanneri* like *exilis* until recently fed solely on lizards. There are two introduced mammals recorded (A. Burbidge, pers. comm.), i.e. black rats on Boxer and house mice on Figure of Eight. Our experience with captive *tanneri* from the latter island indicates that it feeds on mice. Our specimens had little hesitation in taking them. One individual showed a particular liking for hairless rats, suggesting the Boxer Island population probably feeds on these also.

**Medical** - Due to its abundance in high human

density areas the dugite is responsible for most snakebites in Perth. Jelinek and Breheny (1990) analysed the suspected and actual bites for the 10 year period 1980-1990 treated at Fremantle Hospital. This species was involved in 70% of these. The majority of bites occurred in suburban bush or backyards. We are aware of only one suspected fatality as a result of *P.affinis* envenomation in the past 15 years (Sutherland, 1992 and 1995). This may be related to the proximity of metropolitan medical facilities and subsequent rapid treatment.

**Conservation** - There is an obvious lack of information on the insular subspecies, *exilis* and *tanneri*. Our knowledge of these dwarf dugites is almost nil. Only recently (October 1994) we acquired specimens of *tanneri* for private study. Before this the only published data was Worrell's (1961) description. As far as we know there are no *exilis* currently in captivity. One of us has unsuccessfully applied for a licence to keep it. Cogger *et al* (1993) lists both subspecies as 'rare or insufficiently known' as does CALM by including them on the WA Reserve List. We suspect they are listed because of their respectively restricted distributions. We consider neither subspecies to be rare but, as with many WA taxa, they are definitely insufficiently known. *P.a. affinis* is safe, however, a review of this status may be required if it is found to be composite (Ken Aplin, pers. comm.).

**Hybridism** - For some time now it has been suggested informally that there exists *affinis/nuchalis* hybrids, generally on the basis of the banded morph which is similar in colouration to *nuchalis*, but has the midbody scale count of *affinis*. However, as these occur at the extreme south of its range, where *nuchalis* is absent, this can not be the case. In areas of sympatry, no evidence of hybridism has been found by us. We have observed a distinct divergence in the neonates of the two species: *affinis* has a broader, deeper head and thicker body than *nuchalis*, SVL 194-226 (mean 214, N=60) v. 152-240 (mean 203.6, N=53) and mass 4.74-6.82 (mean 5.92, N=60) v. 2.32-6.8 (mean 4.99, N=114).

The only published references to possible hybridism in *Pseudonaja affinis* that we are aware of are in Storr *et al* (1986: 95) suggesting it may hybridise with *nuchalis* and Mengden (1985) concerning a snake from Penong, South Australia, see Plate VIII (H).

**Other observations** - Although *P.affinis* is primarily terrestrial, we have observed it active in low shrubs and have removed the occasional individual from the roofs of houses.

During the warmer months the juveniles especially and to a lesser extent the adults are nocturnal.

Maryan & Robinson (1987) recorded an adult dugite and an adult Rosenberg's monitor (*Varanus rosenbergi*) sheltering beneath the same cover.

De Rebeira (1981) notes the predation of a juvenile *P.a. affinis* by a Red-back Spider (*Lactrodectus mactans*).

The name *affinis* refers to the dugite's then-perceived affinities with *P.nuchalis*. In body colour and pattern it is convergent with this species. However, considering size, build, fecundity and ability to exist in the cooler extreme south-west, it is difficult not to consider it the nearest ecological equivalent of *P.textilis*. In captivity *P.affinis* is a hardy, long-lived, placid snake that is a pleasure to maintain. The males rapidly become human tolerant, while the females usually require a little more patience before they gain your trust.

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**Figure 7**

Map of Australia showing distribution of the mainland dugite or spotted brown snake, *Pseudonaja affinis affinis* (shaded area) and insular subspecies, *exilis* (A), and *tanneri* (B).



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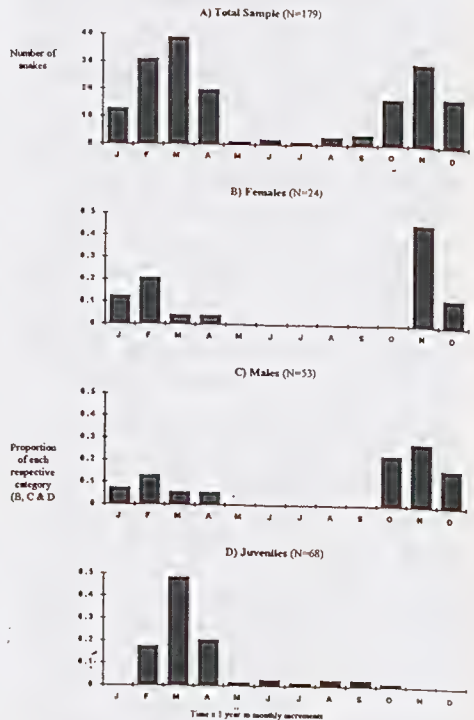
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**Figure 8**

Graphs comparing the proportion of captures relative to month of adult (SVL $\geq$ 60cm) female, male and juvenile (SVL $\leq$ 30cm) *Pseudonaja affinis affinis* suggesting marginally skewed seasonal activity periods in the three groups. Graph A compares the total monthly number of snakes collected including subadults (31-59cm). The seasonality presented here is as would be expected in a species that displays little cold-tolerant behaviour.

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## COMMUNAL EGGLAYING IN THE BROAD-TAILED GECKO (*PHYLLURUS PLATURUS*)

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Communal egg-laying has been recorded for several Australian geckos and this has been summarised by Greer (1989). *Phyllurus platurus* is among those recorded as utilising communal sites (Green, 1973; Ehmann 1992; Doughty & Shine, 1995). Ehmann noted that one site at Oxford Falls, Sydney NSW had been used continuously over a period of 10 years. This note records in more detail the egg clutches found at that site, adds information about the site and oviposition in this species, and extends the known period of usage.

### OBSERVATIONS

The study site is at the upper escarpment edge and has a predominantly north-east aspect. It is on the western side of an incised waterfall. The rock complex in which the oviposition site is situated stands up to 5 metres out of the slope, and consists of cross bedded strata which are very deeply weathered (Fig. 1).

The rock complex received about 60% sunlight (partial tree shading) during the day until about 1600 hours, when the trees growing on the escarpment to the north-west and west cast almost total shadow (1 Feb 1981). The crevice containing the oviposition site never receives direct sunlight due to its aspect (south-western facing entrance), and the rock overhang above.

The oviposition site is a narrow (ca 6cm-10cm wide) vertical crevice underneath a sandstone overhang and at its lowest point the entrance is approximately 1.5m above the ground. The crevice itself is about 1m high (Fig. 1) and extends back into the rock for at least 2m. The floor of the crevice slopes upwards at an angle of 40°. The sides of the crevice immediately above the floor are substantially undercut. These undercuts are partly filled with friable,

organic, well drained soil (Fig. 2) which seems to retain moisture at a more or less uniform level. The soil received some moisture from a trickle of the run-off from the upper surfaces of the rock complex. We did not see this soil waterlogged, even after a period of heavy rain. The first indication we had that it was an egg-laying site was the discovery of four dried egg cases lying at the entrance of the crevice. We could see more egg cases on the floor of the crevice (on 1 Feb 1981). Thirty egg cases were extracted using long thin sticks and a length of wire to dislodge and rake many of them from the crevice floor and associated undercuts.

On 29 November 1981 a further 21 egg cases were removed from the crevice. These represented more than one season's laying as the cases showed at least two (and possibly three) distinctly different degrees of decomposition (insect chewing and/or rot) and discolouration (Fig. 2). Some of these egg cases were loosely scattered on the soil floor of the crevice suggesting that they may have been excavated or dislodged.

In March 1982, 12 egg cases were found, all of recent origin.

In October 1983, 3 egg cases of recent origin were recovered.

In December 1986, 8 egg cases were found. Again these were all recent.

On 6 March 1988, the crevice was examined with a 2.4m Olympus colonoscope (a type of endoscope). Several egg cases could be seen embedded in the soil lying in the undercuts, suggesting that the eggs were deposited into cavities excavated into the soil. The soil filling of the undercuts extended back for at least 1.7 metres and the egg cases seen were associated with the infill (either embedded in it or lying on it).

In March 1994, 16 cases were found, 10 from the 1993/94 season and 6 older cases probably from the 1992/93 season.

In August 1995, 6 egg cases (all of recent origin) were recovered.

In February 1996, 5 egg cases were recovered.

## DISCUSSION

The slightly curved and irregular walls of the crevice makes visual inspection difficult and only eggs on the slope close to the entrance were visible. The back of the crevice was not visible so we could not determine how many eggs were located in the furthest reaches (even with the colonoscope). Despite being able to retrieve some egg cases from beyond the field of view, there is a high probability that some egg cases were not reached or seen.

The position of egg cases within the soil of the undercuts strongly suggests that some of the eggs are oviposited into and covered with soil. The encrusting sand seen on many dislodged cases may be the result of egg-rolling behaviour by female *P.platurus* as described by Doughty and Shine (1995). Loose egg cases within, at and near the crevice entrance suggest that the eggs and/or cases were freed or dislodged from the soil. This may have hap-

pened during hatching or oviposition, or at some other time by the activities of insects, other lizards, or even a predator.

These observations, while intermittent, do indicate yearly usage of the site over a fifteen year period by up to 6 (and possibly 15) females in one season (based on 2 eggs per clutch, Ehmann 1992). Despite the inability to completely check the crevice it appears that the utilisation of the site can vary from year to year as indicated by the low number of egg cases recovered in October 1983.

## ACKNOWLEDGEMENT

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Figure 1.

Photograph of the rock complex and crevice in which the egg cases were found.



Figure 2.

Photograph of the crevice and egg cases.





**A POSSIBLE THREAT TO THE BROAD-HEADED SNAKE  
*HOPLOCEPHALUS BUNGAROIDES*: DEGRADATION OF HABITAT  
BY THE FERAL GOAT *CAPRA HIRCUS*.**

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The Broad-headed Snake *Hoplocephalus bungaroides* has a restricted distribution, occurring within approximately 250 kilometres of Sydney, NSW, predominantly in forested sandstone areas (Griffiths 1987; Swan 1990; Cogger 1992). The species has declined markedly since European settlement (Shine, 1990) and is currently listed as endangered in both the Commonwealth *Endangered Species Protection Act 1992* and the NSW *Threatened Species Conservation Act 1995*.

The species is nocturnal, using exfoliated rocks and rock crevices during autumn, winter and spring and hollow branches in large trees during summer as diurnal retreat sites (Webb and Shine, 1994). The species is highly selective in the choice of exfoliated rock retreats, being found only under unshaded rocks lying on a bare rock substratum and not under shaded rocks or rocks on soil (Webb and Shine, 1994).

Cogger *et al.* (1993) listed the known threats to the survival of the Broad-headed Snake as habitat clearance and fragmentation, urban development, collection of bush rock, and possibly disturbance by frequent visitation and collection of individuals for captivity. Hersey (1980) listed two inherent threats in bushrock collection: the removal of essential rock on rock habitat and the intentional killing of snakes discovered during rock collection. Schlesinger and Shine (1994) noted that bush rock collection also reduced the abundance of Lesueur's Velvet Gecko *Oedura lesueurii*, a major prey species for the Broad-headed Snake. Shine and Fitzgerald (1989) and Shine (1990) highlighted the poor community perception of venomous elapid snakes as a problem in enlisting public support for conservation measures.

Observations at Bugong (34°50'S, 150°26'E) and Kangaroo Valley (34°44'S, 150°27'E) in southern NSW provided evidence of another possible threat to the survival of the Broad-headed Snake: degradation of habitat by the feral goat *Capra hircus*.

Approximately 5000 metres of escarpment edge at Bugong suitable as potential habitat for the Broad-headed Snake, and 1500 metres of similar habitat at Kangaroo Valley, were examined during 1994 and 1995. Both areas searched consisted of west and north facing Nowra Sandstone escarpment tops adjacent to open forest and woodland. Two adult Broad-headed Snakes were found: one at Bugong in October 1994 and one at Kangaroo Valley in July 1995. Both were found under exfoliated rocks on bare rock close to the escarpment edge.

The characteristic faecal pellets of feral goats (Triggs, 1992) were found along approximately 1500 metres of escarpment top at Bugong and 400 metres at Kangaroo Valley. The intensity of usage by goats, as measured by the quantity of goat pellets, was variable. Some areas had only a few scattered goat pellets, while others had goat pellets accumulated in most of the available rock crevices and spaces under exfoliated rocks. At one site in Kangaroo Valley, deposits of goat pellets had provided a medium and seed source for the growth of exotic weeds.

The accumulation of goat pellets in escarpment areas may have an adverse impact on the habitat value of these areas for the Broad-headed Snake. As noted above, key criteria for exfoliated rock shelter sites for the Broad-headed Snake are unshaded rocks on a bare rock substratum. In areas heavily used by goats, such rocks may acquire a substratum of

organic material from the breakdown of accumulated faecal pellets, or become surrounded and shaded by weeds, and thus become less likely to be selected.

Competition and land degradation by the feral goat is currently listed as a key threatening process in the Commonwealth *Endangered Species Protection Act 1992*, and is likely to be similarly listed in the NSW *Threatened Species Conservation Act 1995*. The feral goat has already been implicated in the decline of several mammal species, including the Yellow-footed Rock Wallaby *Petrogale xanthopus* (Lim, 1988) and Brush-tailed Rock Wallaby *Petrogale penicillata* (Short and Milkovits, 1990), but speculation regarding its effect on the habitat of the Broad-headed Snake has not previously been documented. Feral goats favour rocky hillsides (Strahan, 1992) and are therefore likely to occur in the same areas as the Broad-headed Snake wherever their distributions overlap. Whilst habitat degradation by feral goats is unlikely to be a major factor in the decline of the Broad-headed Snake, it may be significant in the more remote parts of the species' range where other threats are minimal.

### ACKNOWLEDGEMENTS

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# SOME LITTERS OF THE EASTERN BLUE-TONGUED SKINK *TILIQUA SCINCOIDES SCINCOIDES* (SCINCIDAE)

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## ABSTRACT

Litter size, neonate size and the relative clutch mass are documented in four captive-born litters of the Eastern Blue-Tongued skink (*Tiliqua scincoides scincoides*). A discussion of ontogenetic colour and pattern change, the timing of parturition, litter size and neonate size is presented.

## INTRODUCTION

While the Eastern Blue-Tongued skink, *T.s.scincoides*, seems to be relatively common in (live) herpetological collections in Australia and overseas (e.g. Mattison 1991, pp.154-60, Broadbuss 1994) there are surprisingly few carefully documented observations of reproduction in this species despite the apparent ease with which it is bred in captivity. Many accounts of reproduction in this species are anecdotal and do not include important information such as neonate and parent female size. The mass of the neonates and the pre/postparturient mass of the parent female are rarely provided and hence the relative clutch mass cannot be determined. In addition there are difficulties in using mass measurements obtained from preserved specimens since it is unclear to what extent the mass has been altered by the preservation process. Shea (1981) has presented the most detailed literature review of *T.s.scincoides* reproductive records, which included new data from captive-born litters and museum specimens. In this article I supplement these observations by describing four litters of *T.s.scincoides* and determining the relative clutch mass for each litter.

## METHODS

Adult *T.s.scincoides* were obtained from remnant grassland in Bundoora (37°42'E,

145°03'S) approximately 15km to the north of Melbourne, Victoria. Specimens were maintained in an open top outdoor enclosure approximately 3.5 X 3.0 X 0.6m at the author's residence 1.5km south of the source population. The snout-to-vent length (SVL) and postparturient mass (PPM) of the parent female and the snout-to-vent length, tail length (TL), head length (HL; as measured from the tip of the snout to the extremal point of interparietal scale) and mass (M) of the neonates were recorded for each litter. Specimen length measurements are given in millimeters (mm) and the mass in grams (g). The snout-to-vent and tail length measurements were taken using a ruler with 1mm gradations, the head length using a vernier caliper with 0.02mm gradations, the mass of each neonate was determined using an Ohaus: Cent-O-Gram balance accurate to 0.01g and the parent female mass using a spring balance accurate to 5g. Unless otherwise stated the measurements were performed within six hours of birth. Neither the parent female nor neonates were offered food until after measurements were taken. The relative clutch mass (RCM) was calculated as the ratio of the total litter mass to the postparturient mass of the parent female (RCM (1) of Greer 1989, p.xvi). For each litter the average (arithmetic mean) and one standard deviation from the mean are quoted for the SVL, TL, HL and M measurements. The error associated with RCM (only) is calculated. All quoted times are in eastern standard time (with no adjustment for daylight savings).

## OBSERVATIONS

Below I detail four reproductive episodes in three female *T.s.scincoides*. The relevant measurements for each litter are presented in Table 1.

### Female 1:

This specimen was acquired as a neonate in February 1982. It became clearly recognisable from other specimens in my collection when within months of acquisition it developed a severe spinal deformity which I believe probably resulted from a vitamin deficient diet (see the observations of Field (1980) and Bartlett (1983)). This deformity however did not appear to restrict the specimen's movements in any way. It reproduced for the first time quite unexpectedly in 1992. Mating was not observed and the male was not seen to show any interest in her. While her abdomen was taut and solid, she was not conspicuously gravid. At the time of parturition she was being temporarily housed in a heated indoor enclosure.

At 1400hrs on 12 February 1992 the enclosure was inspected and found to contain six active neonates. The neonates' skin was quite dry and no yolk sacs were present. I estimated that parturition occurred between 1000-1200hrs earlier the same day. When I attempted to remove the neonates they tried to flee, all except for one that maintained its ground and initiated the typical bloated body and hissing display commonly exhibited in adults.

Later that evening at 1630hrs I inspected the enclosure again and discovered another active neonate. At 0730hrs the next day (13 February) I found a stillborn neonate in the enclosure. The specimen was in utero posture, being curled up with the umbilical cord and yolk sac attached, and the entire lizard enveloped in the transparent chorion sac. The chorion sac was still moist indicating that the specimen was probably born one or two hours prior to being discovered. It did not exhibit any conspicuous abnormalities and was approximately the same size as other neonates in the litter (this specimen is indicated by an asterisk in Table 1: Female 1; 1st Litter).

The female was closely monitored during subsequent days and while somewhat lethargic, she readily consumed fruit and garden snails (*Helix aspersa*).

When inspected on the afternoon of 14 February, two full days after the initial birth, another live neonate was discovered. This was the last making nine in the litter. The post-parturient mass of the female was 385g, the RCM =  $0.278 \pm 0.004$  and average neonate sizes were: SVL =  $86 \pm 0.9$ mm, TL =  $38 \pm 0.9$ mm, HL =  $20.16 \pm 0.42$ mm and M =  $11.98 \pm 0.88$ g (see Table 1: Female 1; 1st Litter).

One week after parturition the parent female was transferred to the outdoor enclosure where she had spent most of her time in captivity, and allowed to overwinter there.

The following year on 27 May an undersized but otherwise apparently normal neonate was found drowned in a water container in the outdoor enclosure. Most specimens had settled in for the winter period and weather conditions during the past few weeks had been characterised by intermittent sunshine and relatively cold nights. On this particular day a number of specimens had emerged to bask. A further search located five live and unusually small neonates curled-up asleep in a dry grassy ground layer. They were each spaced between 10-30cm apart rather than clumped together as many of the adults tend to be after basking. A further two neonates, both dead and badly decayed, were discovered 20cm apart and 1.5m away from the other neonates in a relatively open grassy area. They were both curled up in utero posture and were evidently stillborn. Judging by the condition of both these specimens and the last occurrence of significant adult activity in the enclosure, parturition was estimated to have occurred between 10-14 May. While three female *T.s.scincoides* were present in the enclosure, it was evident from the noticeable weight loss that the litter was produced by Female 1. Again there was no indication during the previous spring and summer periods that mating had occurred nor that Female 1 was gravid, though given the neonate sizes this was not surprising. A thorough search of the enclosure failed to locate any additional neonates. The



litter size was eight. Since the mass at birth of the two badly decayed neonates could not be determined, they were for the purpose of calculating the RCM, each assumed to have a mass equal to the average mass of the other six neonates in the litter. Hence the resulting RCM value is a crude estimate. The post-parturient mass of the female was 325g, RCM approx 0.2 and average neonate sizes were: SVL =  $74 \pm 3.2$ mm, TL =  $32 \pm 1.5$ mm, HL =  $18.30 \pm 0.65$ mm and M =  $7.86 \pm 1.69$ g (see Table 1, Female 1; 2nd Litter). The SVL of Female 1 increased slightly between the 1st and 2nd litters (from 268 to 275mm).

The five live neonates were immediately transferred to an indoor enclosure but failed to thrive and all died within three months. They would almost certainly have perished if allowed to overwinter in the outdoor enclosure since they appeared to lack the fat deposits observed in juveniles overwintering in the field (as indicated by their slender bodies and tails). Apart from their very small body size compared to the first litter (and all other litters, see Table 1 and below), there were several other peculiar features which would seem to indicate that the litter was born prematurely. First, the newborn lizards all exhibited raised and enlarged craniums which were not observed in other neonate *T.s.scincoides*. This condition is a normal characteristic of all but the final embryonic stage of squamate embryos (e.g., Zehr 1962, Muthukkaruppan et al. 1970). Second, the neonates exhibited a distinct lack of coordination and balance. This appeared to be, in large part, a consequence of the difficulty in supporting their relatively large heads. For example, whenever neonates attempted to raise their heads, as would occur often when they encountered a wall of the enclosure, they would immediately lose balance and topple over. They were awkward feeders, having obvious difficulty grasping and manipulating food items. There was also a noticeable lack of coordination of limb movements. None of these features were observed in neonates from other litters. Another peculiar feature was

the timing of parturition. Parturition in local populations of *T.s.scincoides* occurs mainly in February (Turner, in prep.) so the estimated time of birth in early May is very late. I speculate that the litter was aborted in response to the onset of winter conditions with decreasing day light hours and lower night time temperatures. As to why ovulation occurred so late in summer (probably in February) is unclear.

I describe a separate record of an unusually small neonate also found late in autumn. The specimen was found by P.Harris on 28 April 1991 in the south-east of Bundoora. This neonate was in the process of completing its first slough indicating that it had probably been born a matter of days earlier (see comments on neonates below). Its measurements were: SVL = 79mm, TL = 33mm, HL = 19.30mm and M = 7.68g. It is comparable in size to the neonates in Female 1's 2nd litter.

The measurements indicate that this specimen had grown considerably since birth and are consistent with February parturition. The field specimen is significantly larger than the neonates in Female 1's 2nd litter and the late born neonate described above. This size difference is shown in Figure 1. The field specimen was however similar in size to 3 month-old captive reared juveniles.

Figure 1. A comparison of a typical sized juvenile *T.s.scincoides* from the field (top) and a neonate from Female 1's 2nd litter (bottom). The rule is in millimetres (150 mm total length).



### Female 2:

This female when received on 28 January 1992 was conspicuously gravid. Some three weeks later on 16 February it produced 11 live neonates. This particular day was very warm (max 35°C) and parturition occurred between 1200-1430hrs, however it was not witnessed. During this part of the day the enclosure was in full sun; all specimens had taken cover and were inactive. The post-parturient mass of the female was 335g, RCM =  $0.477 \pm 0.007$  and average neonate sizes were: SVL =  $95 \pm 3.4$ mm, TL =  $38 \pm 1.5$ mm, HL =  $21.04 \pm 0.40$ mm and M =  $14.54 \pm 1.46$ g.

### Female 3:

This female when received on 8 January 1994 was quite bloated in appearance and evidently gravid. On 21 February 1994 she produced 17 live neonates. This particular day was warm (max 33°C) and parturition occurred between 1300-1600hrs and was not witnessed. Neonates were first noticed when several scattered from the basking site upon my approach. A group of seven was found clumped together beneath a tin feeding plate. Several more were located beneath rocks in shaded parts of the enclosure. The post-parturient mass of the female was 315g, RCM =  $0.622 \pm 0.010$  and average neonate sizes were: SVL =  $90 \pm 5.2$ mm, TL =  $35 \pm 3.2$ mm, HL =  $20.25 \pm 0.89$ mm and M =  $11.52 \pm 1.95$ g.

## SOME GENERAL COMMENTS ON NEONATES

In all four litters there were no yolk sacs attached to live born neonates when they were discovered, but yolk sacs were present in all stillborn neonates. It is likely that the sacs were consumed by the neonate soon after birth since this behaviour has been observed by other authors (Anon. 1926, Tschambers 1949). Neonates were quite slim at birth and usually commenced feeding immediately.

Dorsal banding pattern in neonates varies both within and between litters. In particular there was considerable variability with respect to the occurrence of bifurcations, ragged edges and cavities in bands. While the band-

ing pattern in some neonates closely resembled one or both parents, others exhibited novel patterns quite different from both parents. For example, half of Female 1's 1st litter had one or more bands which bifurcated on the dorsum while in both parents the bands were without dorsal bifurcations. The same was also true of Female 1's 2nd litter. Both litters did however resemble parental banding patterns by generally exhibiting broad bands and some neonates possessed bands with cavities that were present also in the male parent. There are significant ontogenetic changes in colour and pattern in *T.s.scincoides* (Shea 1981; pers.obs.). I describe some of these changes based on eight individuals (from litters of each of the three females) reared in captivity. Colour and pattern tend to be considerably simpler in neonates than in adults, with fewer distinguishable colour hues and well defined, clearly demarcated banding patterns. In particular, neonates exhibit a strong contrast between the dark brown dorsal bands and lighter ground colour. This tends to make neonate patterns appear rather more vivid and conspicuous compared to adults. The contrast tends to become less distinct with age. There is also noticeable ontogenetic change in the ground dorsal colouration. For example while both parents of Female 1's 1st litter had a grey dorsal ground colour, in the neonates it was yellow. Two of the neonates were retained in captivity and reared to adult size where it was observed that the yellow dorsal ground colouration had all but disappeared and given way to the parental grey. The dorsal banding, ventral flecks and ventral branching patterns were not significantly altered with age. Occasionally individuals developed orange or red ventral flushes. These initially become apparent after about six months of age (in specimens maintained in artificially heated enclosures), and much later in field populations where growth is interrupted by a 4-5 month brumation period (pers.obs.). These ventral flushes are permanent and become deeper and more vivid with age. Neonates belonging to the same litter tend to be very



similar in colour and size (see below) but individuals can be readily distinguished by differences in the dorsal banding pattern alone or by a combination of both dorsal banding and ventral patterns. In neonates the parietal eye is present as a small (approx 0.5mm) indented spot located in the 'center' of the interparietal. The tongue is invariably dark blue-black while in adults the tongue colouration tends to be significantly lighter and more vivid (Tschambers 1949; pers.obs.). Neonates readily resort to using their tongues in threat displays.

At birth the skin has an opaque appearance and usually begins to slough soon after drying which is frequently on the day of birth. Sloughed skin has a distinctive thin papery texture quite different from subsequent sloughs. Fleay (1931) states that 'Skins are shed rapidly as growth proceeds, and the young lizards...had each lost at least one coat though only 24 hours old!'. I have not observed neonates slough more than once, on the day of birth. In four of the neonates retained in captivity (two from the 1st litter of Female 1 and two from the litter of Female 3), the second slough occurred between 27-32 days following birth. This was followed up by the third slough a further 25-36 days later. Neonates from the 2nd litter of Female 1 sloughed a second time after 47-52 days.

A small number of neonates were observed to exhibit malformed head scales, particularly the upper labials. Less common were malformed or incompletely formed head shields, affecting particularly the neonates in Female 1's 2nd litter, though they were not restricted to this litter. In one neonate the most anterior supraocular was divided in two; in another the frontonasal had an incompletely formed suture and in a third individual the frontonasal was strongly skewed to the right and had an incompletely formed suture extended halfway across it. Shea (1982) noted a litter in which neonates had fused head scales.

## DISCUSSION

### Courtship & Copulation

There appear to be few published accounts of courtship behavior and copulation in *T.s.scincoides*.

*coides* despite a number of descriptions of parturition apparently resulting from captive matings (e.g., Shea 1982). Several accounts comment on the 'unexpected' occurrence of parturition with no indication of prior mating and females not appearing to be gravid. Exceptions to this have been Longley (1939) and Tschambers (1949) who respectively observed copulation and attempted copulation, though a description and the duration of the event were not provided. Mattison (1991, p159) states that if male and female *T.s.scincoides* are kept separate then mating often takes place immediately after they are introduced and further that multiple matings are necessary in order to produce young. Permanently housing male and female *T.s.scincoides* together in groups could make observations of courtship and mating less likely because males have unrestricted access to females. Another reason for this discrepancy may be that copulation and courtship in *T.s.scincoides* is relatively brief or infrequent (see comments in Shea (1982)). The failure to witness copulation means that the gestation period cannot be confidently determined. There appears to be just one estimate of the gestation period by Longley (1939) of about 100 days.

I have not witnessed courtship or copulation in *T.s.scincoides* despite having kept small numbers of both sexes (between 3-10 individuals) over a 12 year period. Given that only two of the litters described resulted from matings with other specimens in my collection this is not surprising. It is not entirely clear why reproduction has been so infrequent over this period. This situation is in contrast to *T.nigrolutea* kept under identical conditions where courtship, copulation and parturition have been consistently observed (Turner, in prep.).

### Parturition

Parturition in *T.s.scincoides* was not observed in any of the litters however it has been observed by LeSqu  f (1918), Anon. (1926), Tschambers (1949) and Swan (1972). I have not observed any behavior resembling post-natal care nor any noticeable behavioral

changes other than an increased appetite in post-parturient females (this is in contrast to *T.nigrolutea*; Turner, in prep.). There does not appear to be any mention of parental-care in *T.s.scincoides* in the literature. Tschambers (1949), for example, mentions that one and a half hours after the birth of the last neonate the parent female was fed but does not mention any behavioral change in the female (also see comments by Swan (1972) and LeBreton (1990)).

Except for Female 1's 2nd litter, parturition in the other three litters occurred in February. This is in general agreement with existing published accounts of the timing of parturition in *T.s.scincoides*: 'towards the latter end of February' (Anon. 1926); 9-10 February, 30-31 December, 10 January (Longley 1939); February (Coleman 1944); 7 and 21 February and 14 March (in the same female), 21 February (Swan 1972); 2 and 24 February, 23 November (the latter date occurred in specimens maintained in an artificially heated indoor enclosure; Shea 1981); 28 February (LeBreton 1990); 14 March (D.Green, pers.obs.); 26 April (in an acclimatised USA captive; Phillips 1986). These accounts indicate that parturition in field populations occurs mainly from January to March. The first appearance of neonates in field populations of *T.s.scincoides* to the north and west of Melbourne is consistent with February parturition (pers.obs.).

### Litter & Neonate Size

I compare litter and neonate sizes obtained in this work with published data. Shea (1981) summarises data on litter size and for convenience I indicate the various primary sources, most of which were cited in therein: 17 (LeSouëf 1918); 15 (number of embryos, Flynn 1923); 11 (Anon. 1926); 8 (number of embryos, Willis 1932); usually 10, up to 15 (sample size not stated, Waite 1929, pp.144-5); 18, 10 and 14 (Longley 1939); 5, 5 (Tschambers 1949); 8-20 with average 5.5 (sample size not stated, Bartlett 1983, 1984); 6-20 (sample size not stated, Worrell 1963,

p62); 24 (McPhee 1963, p.113); 11, 9, 10, 5(?), 8, 13 and 8 (Shea 1981); 6, 16-18, 15, 9 (Shea 1982); 10 (Phillips 1986); 3 (LeBreton 1990); 5, 5 (D. Green, pers.obs.). The litter sizes quoted here do not include unfertilised ova which were noted in some of these litters. In Shea (1981) neonate sizes for various litters (litter size in parenthesis) were: SVL =  $98 \pm 2.1$ mm (n=9);  $93 \pm 1.6$ mm (n=7, incomplete),  $85.2 \pm 9.9$ mm (n=18); TL =  $50 \pm 1.5$ mm (n=9),  $43 \pm 2.8$ mm (n=7, incomplete),  $41.0 \pm 6.3$ mm (n=17); HL =  $22.1 \pm 1.2$ mm (n=18). Longley (1939) records an average (total) length ranging between 114-127mm. Tschambers (1949) records: SVL =  $90 \pm 2.5$ mm,  $97 \pm 6.8$ mm (n=5 for both); TL =  $43 \pm 1.5$ mm,  $47 \pm 2.8$ mm (n=5 for both). Combining all data, range for each measurement is: SVL = 62-104mm, TL = 31-52mm and HL = 19.4-24.1mm. Except for Female 1's 2nd litter, the SVL, TL and HL measurements are similar to those recorded in this work; the data in Table 1 almost lie within the ranges exhibited by the combined studies. There is insufficient data to determine the relationship between average neonate size and litter size, especially given the confounding effect of (parent) female size.

Neonate mass is only given for three litters in the literature, two recorded by Tschambers (1949) who found M =  $13.3 \pm 2.1$ g,  $15.5 \pm 0.6$ g (n=5 for both) and LeBreton (1990) M = 15, 16g (n=2); these values are similar to those recorded in this study. Barnett (1977) records a litter size of six in *T.s.intermedia* in which the average total length (120mm) is similar to *T.s.scincoides* neonates, but the mass is not with *T.s. intermedia* neonates having a substantially larger mass (range 20.5-30.0g). Since neither the pre/post-parturient mass of the parent female was stated in any of these accounts, a comparison with the RCM values determined in this study is not possible (and none are quoted in Greer (1989)).

Several authors have noted the occurrence of small numbers of undersized neonates in litters. Shea (1982) mentions a litter of 15 in which two neonates were undersized ('weak-



lings'). The difference in size between these individuals and the rest of the litter was almost 2cm (total length?). This compares with the undersized specimen produced by Female 3, which is substantially smaller in all measurements (e.g., SVL = 71mm vs. 90mm (mean) and M = 5.16g vs. 11.92g (mean); calculation of these means does not include the measurements of the undersized specimen). Swan (1972) also mentions the occurrence of 'runts' in a litter of 17. While small neonate size could result from premature birth, as seems to be the case for Female 1's 2nd litter where all neonates were unusually small, it might also result from an unequal allocation of female resources *in utero*, leading to just a few neonates in a litter being unusually small.

The possibility of geographic variation in the timing of parturition, litter size and neonate size has not been evaluated here. Many of the published accounts pertain to NSW specimens and in some accounts the provenance of specimens is not stated. Given these shortcomings, it is difficult to discern any patterns that might be present. It is observed however that there are no records of January parturition in Victorian *T.s.scincoides* possibly indicating that parturition generally occurs later than in NSW populations. Shea (1993) states that spermatogenesis in northern *T.s.scincoides* populations may peak a few weeks earlier than in southern populations.

### Stillborn Neonates

A number of authors have reported the occurrence of stillborn neonates in *T.s.scincoides* litters. I give the number of stillborn neonates in each litter and the total litter size (in parentheses): 3(18) (Longley 1939), 5(10) (Longley 1944) from a *T.nigrolutea* (female) X *T.s.scincoides*; 7(13) (it was commented however that the parent female was injured, Coleman 1944); 3(3) (Shea 1981); 2(6) (all specimens were deformed, Shea 1982), 4(9) (probable *T.nigrolutea* (female) X *T.s.scincoides*, Shea 1982); 1(3) (LeBreton 1990); 2(5), 3(5) (D.Green, pers.obs.); 2(8), 1(9) (this study); 4(4) (these were all unusually small but otherwise appeared normal; Turner, pers.obs.). By contrast, in *T.nigrolutea* only two of a total of

92 neonates (representing 20 litters from eight females) bred in captivity were stillborn (Turner, in prep.). It would be of interest to determine whether the incidence of stillborn neonates reported in *T.s.scincoides* is related to captive stress.

### ACKNOWLEDGEMENTS

Thanks are due to Darren Green for making available to me his data on *T.s.scincoides*, to Ray Hoser and Gerry Swan for sending me the Bartlett (1983) and Swan (1972) articles respectively. Thanks are also due to Glenn Shea for his improvements to the manuscript.

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**Table 1**

Data for each of the four *T.s.scincoides* litters. For each parent female the snout-to-vent length, litter size, post-parturient mass and relative clutch mass are given. For each neonate the snout-to-length, tail length, head length and mass are given. All length measurements are in millimetres (mm) and mass in grams (g). The following abbreviations are used: n = litter size, SVL = snout-to-length, TL = tail length, HL = head length, M = mass, PPM = post-parturient mass and RCM = relative clutch mass.

Parent Female	SVL	TL	HL	M
Female 1; 1st litter - n=9.				
SVL = 268mm, PPM = 385g, RCM = 0.278±0.004				
	86	38	20.34	12.50
	86	39	20.00	12.07
	87	38	20.64	12.60
	85	37	20.54	11.43
	87	38	20.42	11.90
	86	40	20.26	13.01
	85	37	20.22	12.47
	85	37	19.18	10.06*
	84	38	19.82	10.96



Parent Female	SVL	TL	HL	M
Female 1; 2nd litter – n=8**.				
SVL = 275mm, PPM = 325g, RCM approx 0.2***				
	68	30	17.02	5.98
	74	32	18.00	7.00
	77	33	18.42	7.03
	74	31	18.78	7.89
	77	34	19.02	7.92
	77	30	18.56	11.36

Female 2 – n=11.

SVL = 290mm, PPM = 335g, RCM =  $0.477 \pm 0.007$ .

98	39	21.60	15.92
98	38	21.16	15.61
92	36	21.02	15.02
93	37	20.92	13.62
95	37	21.10	15.99
87	37	20.06	11.00
98	40	21.28	16.22
95	39	21.58	14.55
99	41	20.82	13.32
96	39	20.90	14.71
98	40	21.00	14.04

\* This neonate was stillborn.

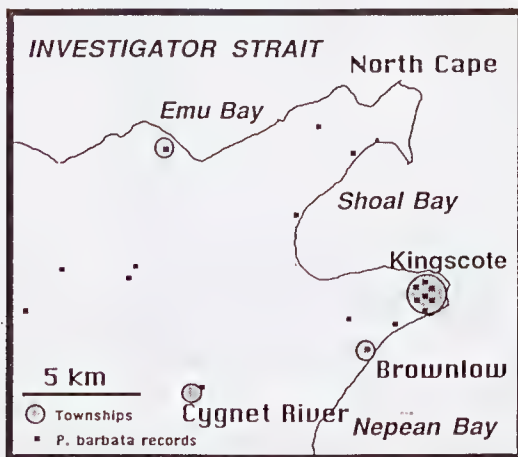
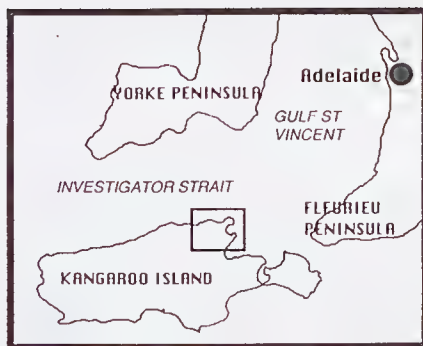
\*\* Two neonates were badly decayed when found (see text) and their details are not included in the table.

\*\*\* This is a crude estimate. See text for details.

Parent Female	SVL	TL	HL	M
Female 3 – n=17.				
SVL = 292mm, PPM = 315g, RCM = $0.622 \pm 0.010$				
	91	38	20.92	12.00
	92	38	20.16	12.88
	91	36	20.68	13.10
	89	37	20.14	13.71
	91	35	20.74	12.61
	95	37	20.72	12.30
	90	35	20.36	11.18
	85	32	20.16	10.65
	89	36	20.00	10.74
	71	24	16.88	5.16
	91	37	20.30	13.30
	91	37	20.40	10.52
	93	38	20.56	10.81
	89	33	20.24	9.78
	95	35	20.28	13.16
	93	36	20.70	12.53
	90	36	21.00	11.42

### Erratum

In Volume 26 (1) the paper '*Pagona Barbata* on Kangaroo Island' by Bill Jenner included a map (Figure 1) on page 29. The map published is incorrect and does not show all the localities mentioned in the text. The correct figure is included here. Our apologies to the author for this error.



## HERPETOLOGICAL NOTES

### PARTIAL TONGUE REGENERATION IN A CAPTIVE BLACK-HEADED PYTHON *ASPIDITES MELANOCEPHALUS* (KREFFT, 1864)

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#### INTRODUCTION

Partial or full tongue loss among snakes is rare, with Hopgood (1980) providing the only published account I could locate. The account did not relate to tongue regeneration. The following observation records a gradual and complete regeneration of the severed portion of a tongue tip.

#### OBSERVATION

The observations relate to an adult male *Aspidites melanocephalus* held between July 9, 1992 and August 22, 1993. The tongue loss occurred on July 17, 1992 during routine feeding. In my experience pythons of this species are awkward and clumsy in both striking and consumption of prey items. An adult *Rattus*

*rattus* managed to turn whilst pinned beneath the snake, biting off one of the tongue tips (See Figure 1). At that moment the snake was investigating the rodents head in an effort to start the swallowing process. Despite the injury the snake continued feeding and no unusual behaviour was noticed during subsequent feeds. Four months later it was obvious that the severed tip was slowly regenerating. This was observed on any occasion that the tongue was visible. A complete tip had formed by eight months (See Figure 2) and full regeneration occurred by fourteen months.

### DISCUSSION

That the python was capable of partial tongue regeneration possibly highlights the importance of, and the reliance on, chemoreception in snakes. Prey detection did not appear to be impeded by the tongue loss in the captive situation. However in the field where scents are followed over considerable distances and where possible mates, rivals and predators must be located, tongue loss could be highly

disadvantageous. Neil Ford (cited by Shine, 1991. p19.) suggested that trail following behaviour may even explain why snakes have forked tongues. "Because its tongue has widely separated tips, a trail-following snake can always compare which of the two tongue tips encountered the strongest scent and hence, was closer to the centre of the scent trail."

The genus *Aspidites* is unique among Australian python genera in lacking labial pits – possibly a link to their prey preference of other reptiles. Perhaps this regeneration highlights a dependence on tongue tips in the location of prey. Further investigation into potential tongue regeneration in other reptiles is warranted.

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**Figure 1**

Extent of tongue loss



**Figure 2**

Extent of regeneration after 8 months





## NOCTURNAL ACTIVITY BY *VARANUS PANOPTES* AT CAPE MELVILLE

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Varanid reptiles are normally considered diurnal animals (Cogger *et al.* 1983) although several instances of nocturnal feeding (Greer, 1989) and nocturnal nesting (Irwin *et al.* in press) have been recorded. Christian (1977) recorded *V. glebopalma* foraging for food during the first couple of hours after sunset while Fyfe (1979, 1980) recorded *V. tristis* feeding near lights outside a building.

On the 13th June 1995, two of us (BL & TF) were on routine patrol to Cape Melville National Park (14°14' S; 144°31' E). The weather during the day was sunny with a maximum temperature of 27°C. Sunset was at 17:40 hours, by 18:30 hours all sunlight had completely faded, however, there was a minimal amount of light associated with a rising full moon. At 19:30 hours and an ambient temperature between 15-18°C, we spotted a large varanid in the headlights of our vehicle. It was walking the track, tongue flicking. We stopped about four to five metres away and observed the animal for several minutes. It continued moving and tongue flicking. The animal was then hand captured and positively identified as *V. panoptes*. It was warm to the touch and was considered to be somewhat warmer than the ambient temperature. At 19:46 hours we drove another kilometre down the road and encountered another large varanid moving and tongue-flicking. This was also identified as *V. panoptes*.

Both animals were not unduly stressed by our presence and their tongue flicking was not a reaction to us. One of the animals was identified as a male by its large size and given that the males have not been recorded assisting in nesting activities, especially at night (Irwin *et al.* in press), it is unlikely that this was the reason for their nocturnal activity. Another possi-

bility is that both animals were males that had just completed an aggressive encounter and the tongue-flicking was utilised to orientate them to their respective territories. Tsellarius & Men'shikov (1994) argue that such an encounter in *V. griseus* would have been accompanied by cloacal drags as well as scuffle marks. None was seen and it is therefore assumed that feeding was the most likely reason for this nocturnal activity. Although no food was seen to be taken, their tongue-flicking action could be inferred as a sign of active feeding (Pianka, 1986).

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## BURROW PLUGGING BY THE FAT-TAILED GECKO, *DIPLODACTYLUS CONSPICILLATUS*

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Many geckos retreat into the ground or hide under rocks, logs or under the bark of living or dead trees. The Australian gecko, *Diplodactylus conspicillatus*, retreats to the round, silk-lined tunnels of a tube spider (*Dyarcys*: Ctenizidae) and is thought to use its short, fat tail to plug the burrow (Greer, 1989; Mascord, 1980). This behaviour is considered to act as an anti-predator defence and may probably also serve to keep the humidity in the burrow high and thus serve as a water conservation function (Greer, 1989). We report here observations that confirm the burrow plugging behaviour, but also indicate that the gecko uses its tail as a false head when disturbed or when unable to retreat to a burrow.

Two adult, gravid, female geckos were collected on the road southwest of Charters Towers, Queensland, on October 28, 1993 under permits issued by the Queensland National Parks and Wildlife Service (T-01044, K-01033). The geckos were observed in the field and in an aquarium in Paluma, then returned to the area of the collection site on November 15, 1993. The aquarium contained water, mealworms and approximately 7 cm of fine sand. Two cardboard tubes measuring approximately 9 cm long with a 1.5 cm diameter were placed in the sand at a 30° to 45° angle.

Unlike many Australian geckos, neither specimen vocalised when captured nor during any subsequent handling. However, both geckos did inflate their bodies, defecate, and perform strenuous tail waves, pushing at the handler's fingers with their tails. At other times, the geckos would curl their tails tightly around the finger. Both geckos measured 5 cm snout-vent. One female appeared to have an original tail, a rarity in adults, that measured 1.6 cm with a

pointed tip. The second female had a regrown tail, measuring 1.2 cm with a rounded tip. Regenerated tails may be even more useful as burrow plugs than original tails because of their rounded tips.

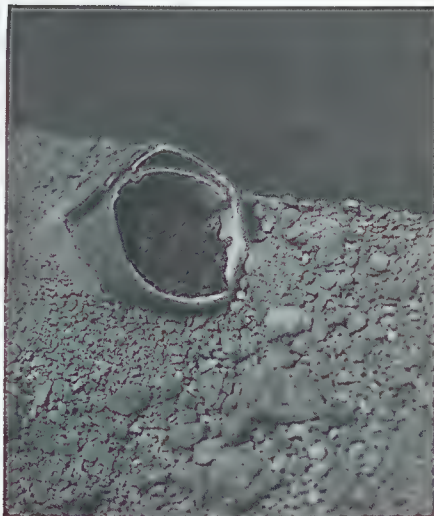
When first placed in the aquarium, the geckos lowered their heads and raised their tails either to or above head level. The legs remained extended or were pulled in toward the body. Slow tail waves usually followed with horizontal side-to-side sweeps, or the tail was raised above the dorsum. The tail wave was striking in its apparent mimicry of the geckos' head movements. When picked up or held with a finger pressed on their back, the geckos would wiggle their tails like a head. Meanwhile, the actual head was held straight out or down and motionless.

When the cardboard tubes were placed in the aquarium, the first female immediately entered a tube head first and disappeared from view. The second female remained outside for 3 hours then entered the unoccupied tube in the same manner as the first female. By then the first female had backed up with the tip of its tail down. This caused the fat tail to bend so as to fill up the space of the tube. The female stopped backing when the tail blocked the entrance of the tube (Fig 1). The next day, both geckos had their tails blocking the burrow entrances. The geckos remained in this position throughout the duration of their captivity. These observations confirm burrow plugging by this gecko and describe a tail movement that mimics the gecko's head. It would be interesting to determine if the plugged burrow also aided in water conservation and whether the gecko is a predator of, or a commensal with, the tube spider.

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**Figure 1**

Photo of captive *Diplodactylus conspicillatus* showing tail-plugging of burrow entrance.

## REDISCOVERY OF THE STRIPED LEGLESS LIZARD, *DELMA IMPAR* (PYGOPODIDAE), ON THE MONARO PLAINS OF NSW

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*Delma impar* is considered a nationally vulnerable species (Cogger *et al*, 1993) and in NSW is listed on Schedule 2 as 'vulnerable'. Nationally the species is known to persist within restricted areas of the ACT (Osborne *et al*, 1993), sites near Bendigo, Ballarat and Melbourne in Victoria (Hadden, 1995) and in NSW from sites near Goulburn (Husband, 1995) and Sutton (Osborne, pers. comm.). Historically there are also records of *D.impar* in NSW from Tumut, Gilmore, Batlow, Tarcutta and Cooma (Shea, 1993; Shea, 1991; Swan, 1990; Jenkins and Bartell, 1980; Kluge, 1974). The single specimen from Cooma is apparently

an individual collected in 1888 from 'Arable' to the south-west of Cooma on the Monaro Plains (36°21'S, 149°02'E) where it is believed *D.impar* was once abundant (Shea, 1993).

The current distribution of populations of *D. impar* is believed to be dependent on the presence of naturally treeless grasslands (Dorrough, 1995; Osborne *et al*, 1993). During cooler climates when grasslands were more extensive, *D.impar* may have had an almost unbroken distribution stretching through the southern tablelands of NSW. The grasslands of the Monaro region represent one of the largest remnants of this habitat. It is therefore



interesting that the presence of *D. impar* on the Monaro is known from only the one collected specimen. A recent survey of grassland sites on the Monaro reconfirmed the presence of the Southern Lined Earless Dragon, *Tympanocryptis lineata pinguicola*, however no *D. impar* were located (Osborne *et al*, 1993).

In October and November of 1995 the authors conducted a survey of six grassland sites on the Monaro. At one locality to the south-east of Cooma (36°16'S, 149°10'E) five *D. impar* individuals were observed, at a rate of approximately 1 individual observed per 150 rocks rolled. All individuals were collected from under or adjacent partially embedded basalt rocks. Basalt rocks were scattered over the site, although were most abundant on the mid and upper slopes. The site was dominated by native perennial tussock forming grasses. Although the region was recovering from a severe drought, due to low grazing pressure considerable vegetative cover was still present. The site has a history of light grazing and has never been ploughed or fertilised (Devereux, pers. comm.), no doubt partially the reason for the continued presence of *D. impar*. Six other species of reptile were also collected at the site, including *T.l.pinguicola*.

The rediscovery of *D. impar* on the Monaro Plains and other recent records elsewhere in NSW (Husband, 1995; Osborne, pers. comm.) suggests that a systematic survey based on known habitat requirements and factors influencing the distribution of *D. impar* needs to be undertaken. Knowledge of the species current distribution and status in NSW is required to ensure conservation strategies can be formulated and implemented with sufficient degree of confidence in their efficacy.

#### ACKNOWLEDGEMENTS

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## HANDBOOK OF LIZARDS. LIZARDS OF THE UNITED STATES AND OF CANADA

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Published by Comstock Publishing Associates  
(Cornell University Press),  
Ithaca, New York.

It is pleasing to see the reprinting of yet another of the Handbooks of American Natural History series in an affordable paperback edition. As with the Handbooks of Salamanders and Snakes (reviewed in *Herpetofauna* 25(1)), Hobart Smith's Handbook of Lizards is an encyclopaedic work deserving a wide readership. Although now half a century old, it has never become outdated, due to the overwhelming amount of original information presented and the precise referencing of all observations.

Each species and subspecies recognised is identifiable by dichotomous keys and in most cases black and white photographs, often of dorsal, lateral and ventral pattern. The source of the animals photographed is clearly stated (unlike the recent trend in Australian herpetological guides), allowing one to follow up any apparent anomalies. Each species account includes details of distribution, type, locality, size, coloration, scalation, particular features allowing identification, habits and habitat, and references. The ecological details included are liberally salted with quotes from field collectors, making them most readable.

One additional feature of each account is a 'Problems' section, in which unknown or problematic features of systematics or ecology are highlighted. This simple feature has provided the stimulus for much subsequent research on the North American lizard fauna.

Maps are grouped in a section towards the end of the volume, while a final section gives species lists for each state. To the Australian reader, it may seem remarkable that much of northern North America lacks any lizards, although as in Australia, the drier desert and semi-arid regions have the highest species diversity.

Inevitably, a facsimile reprint of a fifty year old reference book will suffer from changes in nomenclature and improved systematic knowledge. However, the effect of such changes is here minimised by the inclusion of a new foreward by Darrel Frost of the American Museum of Natural History, which includes a table of modern equivalents for Smith's taxa. In comparison to the Australian lizard fauna, these changes have been remarkably few. Smith lists 140 species and subspecies (four subspecies given only in footnotes due to the appearance of taxonomic papers after his manuscript was completed), of which five were introduced, and three others included on the basis of a probable occurrence in the USA. The populations of two of the introduced species have since died out, while the three species suspected of being present are still not confirmed. This leaves 135 species and subspecies. In contrast, Frost lists 211 species and subspecies. Only eight of the taxa identified by Smith have been synonymised, although the names may have changed. Most of the increase in numbers is due to additional introduced species (21 now present), recognition of many parthenogenetic species among the teiids, and additional subspecies, particularly among the smaller iguanian lizards such as *Sceloporus*. As a general reference on the North American lizards, Smith's volume has yet to be superseded.

Glenn Shea



## BOOK REVIEW

### THE TAIPAN. THE WORLD'S MOST DANGEROUS SNAKE

by P. Masci and P. Kendall.  
Published by Kangaroo Press, Kenthurst.

'The Taipan' is a unique addition to the popular literature on Australian snakes, in being devoted almost entirely to a single species. This restriction may be warranted, as an aura of fear, at times verging on hysteria, has developed about the taipan (*Oxyuranus scutellatus*) in the 67 years since the potency of its venom became known to science. This aura has spawned a voluminous literature, both scientific and popular, much of the latter almost mythical in nature.

'The Taipan' attempts to draw together much of this literature, from medical to ecological, and from scientific studies to newspaper reports and even many verbal accounts, in a single lavishly illustrated large-format volume, with an extensive (two page) list of references. The book will certainly appeal to the general reader with limited previous exposure to snakes. At this level, it is informative and accurate, and tells an engrossing story, particularly regarding the history of European discovery and experience with the snake, with numerous insights into the personalities involved. However, it will likely leave the more informed reader unsatisfied and looking for more substance.

Although it is extensively illustrated with colour and black and white photographs, including numerous photographs of the species or parts of it (venom glands, fangs, scales, sloughing, eggs, hatching, hatchlings, swallowing (including x-rays!), skulls and venom), and lots of photographs, many from newspaper reports or archival sources, of the people involved in research on taipans, and the victims of bites, one gets the feeling that the authors have not been selective in their choice of photographs and have not made the best use of the material. For example, I count 11 photographs of

taipan heads, including the cover illustration (also reproduced in black and white on p. vi), which seem to have no purpose apart from decoration. Among the captions applied to these are: 'the taipan is one of the world's most dangerous snakes', 'the taipan is a protected species and plays an important role in the natural environment', 'the keen perceptive eye of the Taipan is constantly alert' and 'the large red eye of the Taipan and the protruding superocular scale give it a villainous appearance'. Many of these and other photographs are not particularly clear, although whether this is a fault of the original illustrations or the reproduction is unknown. This is particularly noticeable in some photographs that would have been better presented as drawings, such as the skull photographs (p. 67) and the graph of venom yield following successive bites (p. 52). Similarly, the text is often disjointed, with case histories of snake bite scattered over the first two chapters ('The Eastern Taipan and Man' and 'Taipan Snakebite'), lengthy slabs of text from the literature cited (accurately) verbatim, without comment, and curiously, a lack of balance between the coastal Australian taipan (*Oxyuranus scutellatus scutellatus*), which fills much of the book, and the New Guinea taipan (*Oxyuranus scutellatus canni*) and inland taipan (*Oxyuranus microlepidotus*), which are mostly relegated to chapters at the end, five and two pages respectively.

The lack of clear reference citations in the text often makes it difficult to determine the source of much of the information presented, with a number of sources apparently not listed (for example, p. 18, 'the first published report of the production of antivenom in Australia was in 1906, by Dr F. Tidswell of the New South Wales Department of Public Health', yet no



listing of a paper by Tidswell in the list of references; similarly, p. 12: 'as early as 1890, a Dr H.C. Garde from northern Queensland wrote in the *Medical Journal of Australia*: 'I have an acquaintance who witnessed four out of seven people bitten by Death Adders recover, but I have attended funerals of all twelve people bitten by 'brown coloured snakes', without giving full details of this reference). None of the newspaper reports scattered so liberally through the text makes it into the list of references.

Although much of the text is written for the lay reader, with simple explanations of features of taxonomy and nomenclature, the medical literature, often quoted verbatim, will prove confusing to the general public. These technicalities often rub shoulders with the more general explanations in a curious amalgam. For example, on page 8: 'Kellaway and Williams also reported the symptoms the animals displayed after controlled subcutaneous injections of the venom. They developed muscular paralysis and died from asphyxia, ... In vitro experiments showed that the venom contained a thrombase, a potent blood-clotting component which clotted citrated plasma, and also had a weak haemolytic property' followed two paragraphs later by 'when Thomson returned to the south with four live specimens,

he examined them, found that *Pseudechis scutellatus* of Peters and *Oxyuranus macleani* of Kinghorn appeared to be the same, and considered that Kinghorn was right to distinguish the snake from the genus *Pseudechis*'.

These deficiencies are unfortunate, as none are unavoidable, and a little more thorough editing would have considerably enhanced the book without detracting from its charm.

One final plea, from a biologist based in New South Wales, where the eastern taipan is legislatively listed as 'endangered': like some previous scientific literature, this book includes a map with spot localities in north-eastern New South Wales, and adds the statement: 'they have also been found as far south as Murrumbidgee and Mount Warning. The farthest south so far is Grafton, New South Wales ...'. Where is the evidence for these records? They do not appear to be based on preserved specimens stored in museums. Snakes are frequently misidentified by the general public, and unless specific details of scale counts and identification of the source of the observation are given, these records from New South Wales are not verifiable. Is there any real evidence that the taipan is present in the state?

Glenn Shea

## NOTES TO CONTRIBUTORS

*Herpetofauna* publishes articles on any aspect of reptiles and amphibians. Articles are invited from interested authors particularly non-professional herpetologists and keepers. Priority is given to articles reporting field work, observations in the field and captive husbandry/breeding.

All material must be original and must not have been published elsewhere.

### PUBLICATION POLICY

Authors are responsible for the accuracy of the information presented in any submitted article. Current taxonomic combinations should be used unless the article is itself of a taxonomic nature proposing new combinations or describing new species.

Original illustrations will be returned to the author, if requested, after publication.

### SUBMISSION OF MANUSCRIPT

Two copies of the article (including any illustrations) should be submitted. Typewrite or handwrite (neatly) your manuscript in double spacing with a 25mm free margin all round on A4 size paper. Number the pages. Number the illustrations as Figure 1 etc., Table 1 etc., or Map 1 etc., and include a caption with each one. Either underline or italicise scientific names. Use each scientific name in full the first time, (eg *Delma australis*), subsequently it can be shortened (*D. australis*). Include a common name for each species.

The metric system should be used for measurements.

Place the authors name and address under the title.

Latitude and longitude of any localities mentioned should be indicated.

Use the Concise Oxford Dictionary for spelling checks.

Photographs – black and white prints are pre-

ferred but colour slides are acceptable.

Use a recent issue of *Herpetofauna* as a style guide.

A computer disc may be submitted instead of hard copy but this should not be done until after the manuscript has been reviewed and the referees' comments incorporated. Computer discs must be HD 1.44 mb 3.5" in Word for Windows; Wordperfect; Macintosh or ASCII. Any disc must also be accompanied by hard copy.

Articles should not exceed 12 typed double spaced pages in length, including any illustrations.

### REFERENCES

Any references made to other published material must be cited in the text, giving the author, year of publication and the page numbers if necessary. At the end of the article a full reference list should be given in alphabetical order. (See this journal).

Manuscripts will be reviewed by up to three referees and acceptance will be decided by an editorial committee. Minor changes suggested by the referees will be incorporated into the article and proofs sent to the senior author for approval.

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### REPRINTS

The senior author will receive 25 reprints of the article free of charge.





Fat-tailed gecko (*Diplodactylus conspicillatus*) from Charters Towers area, Queensland. See paper on page 51.



Broad-tailed gecko (*Phyllurus platurus*) from Oxford Falls, Sydney. See paper on page 35 (photo: G. Swan).